APPRENTICESHIP TRAINING

Refrigeration and Air Conditioning Mechanic Program

Alberta
LEARNING
Apprenticeship and Industry Training

ALBERTA LEARNING CATALOGUING IN PUBLICATION DATA

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Refrigeration and Air Conditioning Mechanic

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Course Outline

Apprenticeship and Industry Training System

Apprenticeship is post-secondary education with a difference. It helps ensure Alberta has a steady supply of highly skilled employees, the foundation of our economy's future health and competitiveness.

Apprentices in more than 50 trades and crafts spend between one and four years learning their trade - 80% of the time on the job under the supervision of a certified journeyman or qualified tradesperson. The balance of the program is technical training in the theory, skills and technologies of their trade.

To become certified journeymen apprentices must learn theory and skills, and they must pass examinations. Requirements for certification—including the content and delivery of technical training—are developed and updated by the Alberta Apprenticeship and Industry Training Board (the Board) and a network of local and provincial industry committees.

The graduate of the Refrigeration and Air Conditioning Mechanic apprenticeship training is a journeyman who will:

- have a through knowledge of the principle components of refrigeration systems, heat/cool units and air conditioning.
- have a through knowledge of the electrical and automatic controls used in all aspects of the refrigeration and air conditioning industry.
- be capable of assembling, installing or over hauling all components.
- have an intimate knowledge of other mechanical trades, which contribute to refrigeration and air conditioning systems.
- be proficient in the use of test instruments.
- exercise good judgment and resourcefulness in construction, maintenance and workplace health and safety.

Apprenticeship and Industry Training Committee Structure

While government supports Alberta's apprenticeship and industry training system, it is driven by industry, a term which includes both employers and employees. The Board, with the support of Alberta Learning, oversees the system. But the system relies on a network of industry committees. These committees include local and provincial apprenticeship committees (LACs and PACs) in the designated trades and occupational committees (OCs) in the designated occupations, as well as other committees such as provisional committees established before the designation of a new trade or occupation comes into effect. All these committees are composed of equal numbers of employers and employees. The network of industry committees is the foundation of Alberta's apprenticeship and industry training system.

Local Apprenticeship Committees

Wherever there is activity in a trade, the Board can set up an LAC. The Board appoints equal numbers of employees and employers for terms of up to three years. The committee appoints a member as presiding officer. Local Apprenticeship Committees:

- monitor the apprenticeship system, and the progress of apprentices in their trade, at the local level.
- help settle certain kinds of issues between apprentices and their employers.
- recommend improvements in apprenticeship training and certification to their trade's provincial apprenticeship committee.
- make recommendations to the Board regarding the appointment of members to their trade's PAC.

Provincial Apprenticeship Committees (PAC)

The Board establishes a PAC for each trade and, based on PAC recommendations, appoints a presiding officer and equal numbers of employees and employers for terms of up to three years. Most PACs have nine members. Provincial Apprenticeship Committees:

- identify the training needs and content for their trade.
- recommend to the Board the standards for training and certification for their trade.
- monitor the activities of local apprenticeship committees in their trade.
- make recommendations to the Board about the designation of trades and occupations.
- determine whether training of various kinds is equivalent to training provided in an apprenticeship program in the trade.
- may participate in resolving any apprenticeship-related disputes between employers and employees.

Refrigeration and Air Conditioning Mechanic PAC Members

Mr. W. Lowrie	Edmonton	Presiding Officer
Mr. A. Brown	Calgary	Employer
Mr. A. Fenniak	Fort McMurray	Employer
Mr. W. McMullen	Red Deer	Employer
Mr. D. Garland	Calgary	Employee
Mr. J. Hajdu	Calgary	Employee
Mr. D. Clark	Edmonton	Employee

The Alberta Apprenticeship and Industry Training Board

The mandate of the Alberta Apprenticeship and Industry Training Board relates to the standards and requirements for training and certification in programs under the *Apprenticeship and Industry Training Act*. The Board provides advice to the Minister of Learning on the training and certification of people in designated trades and occupations and on the needs of the Alberta labour market for skilled and trained persons. The Board also makes orders and regulations respecting standards and requirements for apprenticeship programs and the training of apprentices and for training and certification in designated trades and occupations, and the criteria or requirements for granting and recognizing trade and other certificates.

The 13-member Board consists of a chair, eight members representing trades and four members representing other industries. Employer and employee representatives equally represent the trades and other industry members.

Safety Education

Safe working procedures and conditions, accident prevention and the preservation of health are of primary importance in apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of government, employers, employees and the public. Therefore, it is imperative that all parties become aware of circumstances that may lead to injury or harm. Safe learning experiences and environments can be created by controlling the variables and behaviours that may contribute to or cause an accident or injury.

It is generally recognized that a safe attitude contributes to an accident free environment. Everyone will benefit as a result of a healthy, safe attitude towards prevention of accidents.

A tradesperson is possibly exposed to more hazards than any other person in the work force and, therefore, should be familiar with and apply the Occupational Health and Safety Act, Regulations and Code dealing with personal safety and the special safety rules applying to each task.

Legal and Administrative Aspects of Safety

Accident prevention and the provisions of safe working conditions are the responsibilities of an employer and employee.

Employer's Responsibilities

The employer is responsible for:

- providing and maintaining safety equipment and protective devices.
- ensuring proper safe work clothing is worn.
- enforcing safe working procedures.
- providing safeguards for machinery, equipment and tools.
- observing all accident prevention regulations.
- training employees in the safe use and operation of equipment.

Employee's Responsibilities

The employee is responsible for:

- working in accordance with the safety regulations pertaining to the job environment.
- working in such a way as not to endanger themselves or fellow employees.

Workplace Health and Safety's Responsibilities:

Workplace Health and Safety (Alberta Human Resources and Employment) will conduct periodic inspections of the workplace to ensure that safety regulations for industry are being observed.

Technical Training Establishment

Alberta Learning, Apprenticeship and Industry Training offer your apprenticeship training program. Staff and facilities for delivering the program are supplied by Southern Alberta Institute of Technology (main campus).

Procedures For Recommending
Revisions To The Course Outline

Apprenticeship and Industry Training, Industry Programs and Standards has prepared this course outline in partnership with the Refrigeration and Air Conditioning Mechanic Provincial Apprenticeship Committee.

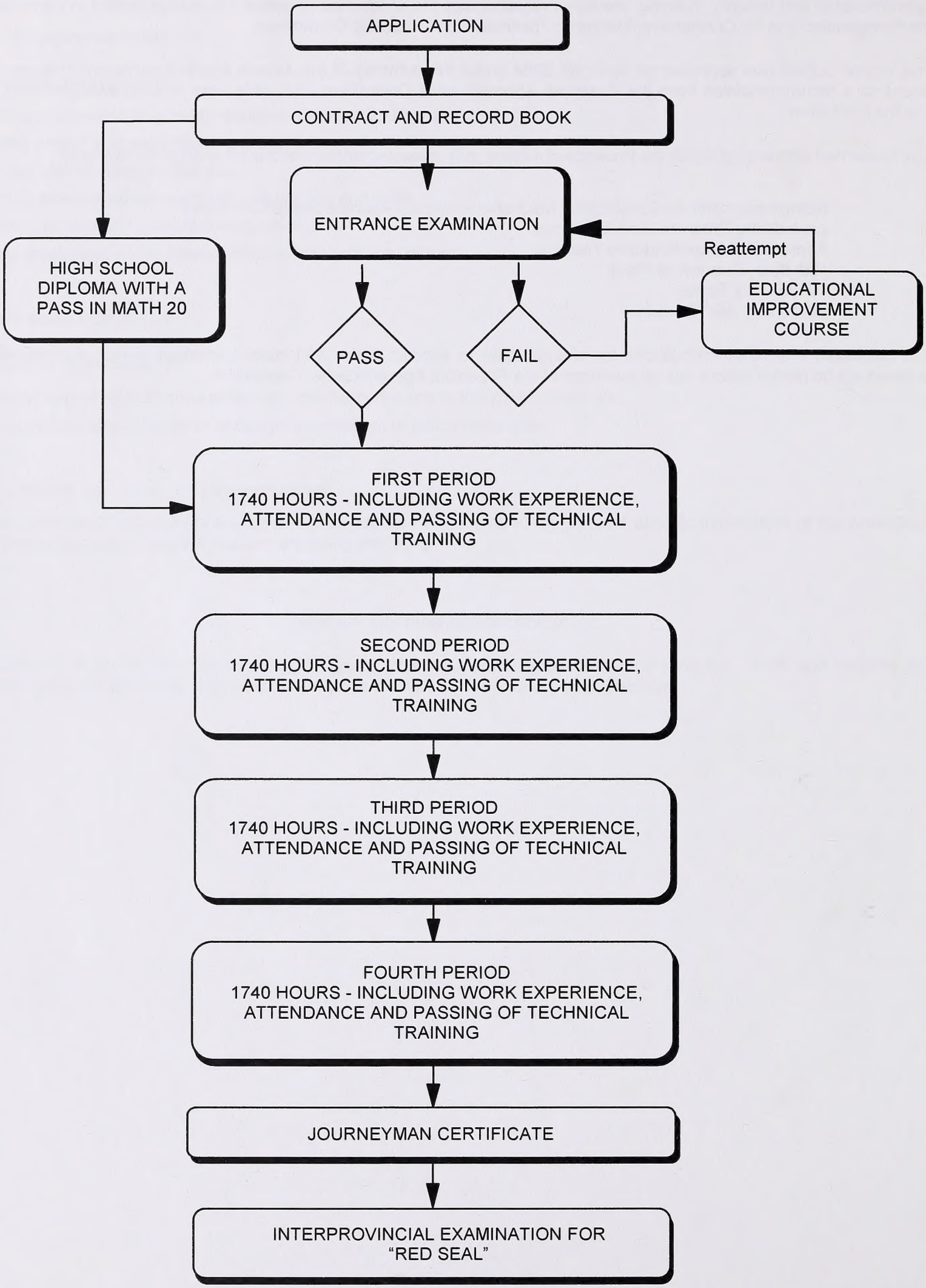
This course outline was approved on June 26, 2004 under the authority of the Alberta Apprenticeship and Industry Training Board on a recommendation from the Provincial Apprenticeship Committee. Valuable input is acknowledged from industry and the institutions.

Any concerned citizen or group in the Province of Alberta may make recommendations for change by writing to:

Refrigeration and Air Conditioning Mechanic Provincial Apprenticeship Committee
c/o Industry Programs and Standards
Apprenticeship and Industry Training
10th floor, Commerce Place
10155 - 102 Street
Edmonton, AB T5J 4L5

It is requested that recommendations for change refer to specific areas and state references used. Recommendations received will be placed before regular meetings of the Provincial Apprenticeship Committee.

Apprenticeship Route Toward Certification



Refrigeration and Air Conditioning Mechanic Training Profile

FIRST PERIOD

(8 Weeks/30 Hours per Week – Total of 240 Hours)

SECTION ONE

REFRIGERATION AND AIR CONDITIONING SHOP
80 Hours

A	B	C
Safety 4 Hours	Tools and Instruments 10 Hours	Maintenance Skills 20 Hours
D	**E**	**F**
Pipe Working Skills, Soldering and Brazing 20 Hours	Leak Testing and Evaluation 9 Hours	Manual Valves and Accessories 4 Hours
G	**H**	
Automatic Flow Controls and Applications 8 Hours	Compressor Identification 5 Hours	

SECTION TWO

REFRIGERATION AND AIR CONDITIONING THEORY
64 Hours

A	B	C
Refrigeration Industry Introduction 2 Hours	Relevant Codes and Safety 4 Hours	Refrigeration Principles and Gas Laws 20 Hours
D	**E**	**F**
Vapour Compression Cycle and Introduction to Pressure Enthalpy Diagrams 20 Hours	Refrigerants and Oils 10 Hours	Air Properties 3 Hours
G	**H**	
Customer Relations 4 Hours	Introduction to Blueprint Reading 1 Hour	

SECTION THREE

HEATING THEORY AND SHOP
16 Hours

A	B	C
Gas Fundamentals and Heating System Components 8 Hours	Gas Burners and Combustion 6 Hours	Relevant Codes 2 Hours

SECTION FOUR

CONTROL THEORY
32 Hours

A	B
Control Fundamentals 20 Hours	Control Applications 12 Hours

SECTION FIVE

ELECTRICAL THEORY AND SHOP
48 Hours

A	B	C
Electrical Principles 12 Hours	Electrical Equipment 10 Hours	Circuits and Systems 10 Hours
D	**E**	
Relays and Contactors 8 Hours	Electrical Safety 8 Hours	

SECOND PERIOD

(8 Weeks/30 Hours per Week – Total of 240 Hours)

SECTION ONE

REFRIGERATION AND AIR CONDITIONING SHOP
80 Hours

A	B	C
Evaporator Feed Controls 12 Hours	Hermetic Compressors and Circuit Components 14 Hours	Automatic Flow Controls and Applications 10 Hours
D	**E**	**F**
Refrigeration Accessories 6 Hours	Service Refrigeration Systems 24 Hours	System Troubleshooting 8 Hours
G		
Retrofitting and Conversions 6 Hours		

SECTION TWO

REFRIGERATION AND AIR CONDITIONING THEORY
64 Hours

A	B	C
Refrigeration Effect 4 Hours	Compressors 8 Hours	Evaporators and Condensers 6 Hours
D	**E**	**F**
Evaporative Condensers and Cooling Towers 5 Hours	System Analysis 32 Hours	Relevant Codes 3 Hours
G	**H**	
Air Conditioning Fundamentals 4 Hours	Blueprint Analysis 2 Hours	

SECTION THREE

HEATING THEORY AND SHOP
32 Hours

A	B	C
Gas Orifices and Pilot Devices 8 Hours	Basic Gas Control Systems 12 Hours	Air Supply and Venting 12 Hours

SECTION FOUR

CONTROL SYSTEMS THEORY AND SHOP
32 Hours

A	C
Control Systems 32 Hours	

SECTION FIVE

ELECTICAL THEORY AND SHOP
32 Hours

A	B	C
Transformers 2 Hours	Motors 24 Hours	Troubleshooting Electrical Problems 5 Hours
D		
Basic Electrical Code 1 Hour		

THIRD PERIOD
(8 Weeks/30 Hours Per Week – Total of 240 Hours)

SECTION ONE

REFRIGERATION AND AIR CONDITIONING SHOP — 72 Hours

A	B	C
Defrosting — 10 Hours	Ice Cubers and Flakers — 4 Hours	Advanced Installation of Refrigeration Systems — 42 Hours

D	E
Compressor Maintenance and Overhaul — 8 Hours	Troubleshooting Advanced Refrigeration Systems — 8 Hours

SECTION TWO

REFRIGERATION AND AIR CONDITIONING THEORY — 48 Hours

A	B	C
Refrigeration System and Component Design — 14 Hours	Refrigeration and Air Conditioning Load Calculations — 8 Hours	Food Preservation — 2 Hours

D	E	F
Piping Design and Practices — 12 Hours	Industrial Systems — 8 Hours	Relevant Codes — 4 Hours

SECTION THREE

HEATING THEORY AND SHOP — 32 Hours

A	B	C
Relevant Codes — 2 Hours	Electronic Ignition Systems — 24 Hours	Fan Assisted Venting Systems — 6 Hours

SECTION FOUR

ELECTRICAL SYSTEMS — 16 Hours

A	B
Three Phase Fundamentals — 6 Hours	Motors — 10 Hours

SECTION FIVE

AIR CONDITIONING THEORY — 32 Hours

A	B	C
Air Conditioning Systems — 6 Hours	Fans and Mechanical Drive Systems — 4 Hours	Advanced Air Properties — 8 Hours

D	E	F
Air Instruments and System Balancing — 4 Hours	Unitary Air Conditioning Systems — 6 Hours	Filtration — 4 Hours

SECTION SIX

AIR CONDITIONING SHOP — 32 Hours

A	B	C
Fans and Belts — 4 Hours	Ventilation Systems — 6 Hours	Unitary Equipment — 20 Hours

D
Air Instruments — 2 Hours

SECTION SEVEN

CONTROL SYSTEMS — 8 Hours

A
Pneumatic Control Systems — 8 Hours

FOURTH PERIOD
(8 Weeks/30 Hours Per Week – Total of 240 Hours)

SECTION ONE

REFRIGERATION SHOP — 48 Hours

A	B	C
Industrial Compressor Tear-Down — 10 Hours	Compound Compression Systems — 8 Hours	Multiplex Systems — 10 Hours
D	**E**	**F**
Centrifugal Operation and Inspection — 8 Hours	Ultra Low Cascade System — 8 Hours	Artificial Ice Rinks — 2 Hours
G	**H**	
High Efficiency Purge Systems — 2 Hours	Microprocessor Control — 6 Hours	

SECTION TWO

REFRIGERATION THEORY — 24 Hours

A	B	C
Industrial Refrigeration Systems — 6 Hours	Piping Design — 2 Hours	Absorption and Centrifugal Chillers — 4 Hours
D	**E**	**F**
Multiplex Piping and Operation — 4 Hours	Ultra-low Systems and Cryogenics — 2 Hours	Troubleshooting Systems and Components — 4 Hours
G		
Relevant Codes — 2 Hours		

SECTION THREE

HEATING THEORY AND SHOP — 32 Hours

A	B
Troubleshooting Gas Fired Equipment — 16 Hours	Operation of Roof Top Heat/Cool Units — 16 Hours

SECTION FOUR

ELECTRICAL SYSTEMS — 16 Hours

A	B
Advanced Electrical Troubleshooting — 8 Hours	Schematic Diagrams — 8 Hours

SECTION FIVE

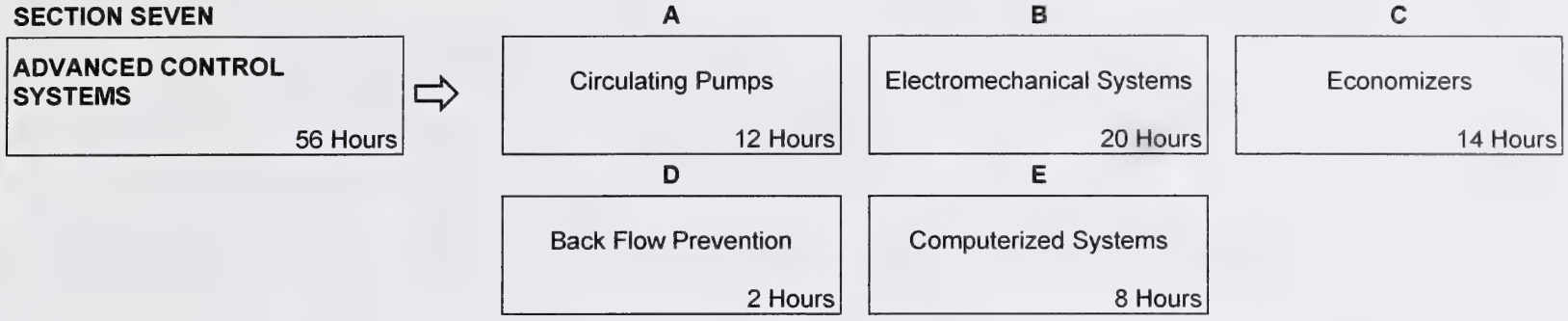
AIR CONDITIONING THEORY — 48 Hours

A	B	C
Air Conditioning Systems — 4 Hours	Troubleshooting Air Conditioning Systems — 6 Hours	Air Conditioning Cooling Load Calculations — 6 Hours
D	**E**	**F**
Duct Systems and Filters — 6 Hours	Mechanical Drives for Fan Systems — 4 Hours	Specialized Control Systems — 4 Hours
G	**H**	**I**
Installation of Air Conditioning Equipment — 6 Hours	Energy Management and Indoor Air Quality — 4 Hours	Advanced Blueprint Reading — 8 Hours

SECTION SIX

AIR CONDITIONING SHOP — 16 Hours

A	B	C
Installation — 4 Hours	Instruments — 6 Hours	Troubleshooting — 6 Hours



NOTE: The hours stated are for guidance and should be adhered to as closely as possible. However, adjustments must be made for rate of apprentice learning, statutory holidays, registration and examinations for the training establishment and Apprenticeship and Industry Training

FIRST PERIOD TECHNICAL TRAINING
REFRIGERATION AND AIR CONDITIONING MECHANIC TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS COURSE THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

Due to the nature of the work of the Refrigeration and Air Conditioning Mechanic, it is imperative that safety be emphasized throughout this course.

Special emphasis should be placed on weak areas of theory and lab, which are evident from progressive tests and examinations administered throughout the course. The time required for such examinations and testing shall be allowed for in each area of instruction.

SECTION ONE: ..... REFRIGERATION AND AIR CONDITIONING SHOP ..... 80 HOURS

A. Safety ..... 4 Hours

1. Describe personal and equipment safety.
2. List the sections in the Occupational Health and Safety (OH&S) regulations that affect the refrigeration and air conditioning industry.
3. Describe Worksite Hazardous Material Information System (WHMIS) regulations.
4. Describe the safe storage of stock and equipment in service vehicles.
5. Describe hazards associated with the following:
   a) refrigerants
   b) toxic chemicals (non-refrigerant)
   c) electrical hazards
   d) fire and flame
   e) high pressure fluids

B. Tools and Instruments ..... 10 Hours

1. Identify, select, maintain and store common hand tools.
2. Identify, select, maintain and store the following specialized refrigeration and air conditioning tools:
   a) capacitor testers
   b) electrical meters — analogue/digital
   c) gauges and manifolds
   d) humidity recorders
   e) hygrometers
   f) pipe cutters
   g) temperature recorders
   h) thermometers and probes
3. Identify, select and maintain the following power tools:
   a) drills
   b) hammers
   c) impact wrenches
   d) cutters
   e) threaders
   f) grinders
   g) saws
4. Describe grounded and double insulated power tools.
5. Measure using the following instruments:

a) imperial and metric measuring tapes
b) Vernier callipers
c) micrometers

6. List, describe, and use thermometers.

C. Maintenance Skills ..... 20 Hours

Moving Machinery

1. List different types of bushings and bearings.
2. List the types of sheaves used in industry.
3. Check bearings for wear.
4. State causes of bearing failures.
5. Change shafts, bearings, and sheaves.
6. Lubricate different types of bushings and bearings.
7. Install solid and adjustable sheaves.
8. Check sheaves for wear.
9. List the different belt categories.
10. Select the proper belt type for a given application.
11. List causes for belt failure.
12. Install and adjust belts.
13. Align drives.

Fans

1. List fan blade and fan assembly problems.
2. Clean fan wheels and blades.
3. Replace axial and radial fan blades with attention to:
   a) placement within the housing
   b) set screws (change setting)
   c) checking rotation

Heat Transfer Devices

1. Clean evaporators and condensers.
2. Straighten fins.

Ice Making Equipment

1. Clean ice machines.

Humidifiers

1. Describe various types of humidifying equipment, installation, service and safety procedures.

D. Pipe Working Skills, Soldering and Brazing ..... 20 Hours

Materials

1. Select air conditioning and refrigeration piping materials using the following criteria:
   a) handle the piping materials correctly and safely
   b) use hard and soft drawn copper tube

c) describe the difference between nominal and ACR tubing and steel pipe

Cutting and Bending of Copper Pipe and Tubing

1. Bend copper tubing using mechanical benders.
2. Cut and ream soft and hard drawn copper tubing.

Joining Methods

1. Flare, swage and assemble copper tubing.
2. Use brazing materials to assemble copper piping.
3. Describe the safe use of acetylene equipment and accessories.
4. Use acetylene equipment and accessories safely.
5. Add nitrogen to tubing while brazing in a safe manner.
6. Use the following brazing methods:
   a) 45% silver bearing solder wire and flux
   b) 15% silver and phosphorus rod
   c) 95/5 soft solder

Cutting and Threading of Steel Pipe

1. Identify, select and assemble fittings used in copper and steel piping systems.
2. Use mechanical threader to cut threads on steel pipe.
3. Fit threaded pipe together using proper fitting methods.

Pipe Hangers and Supports

1. Select and use hangers, clamps and supports.
2. Identify, select and use proper fastening devices.

E. Leak Testing and Evacuation ..... 9 Hours

Leak Testing Methods

1. Describe safe leak detection methods according to the B-52 Mechanical Refrigeration Code and the Canadian Code of Practice.
2. Evaluate halide torch leak detection.
3. Use leak detecting soap solutions.
4. Describe leak detection of ammonia systems using sulphur sticks and litmus paper.
5. Safely use nitrogen for leak testing.
6. Use electronic leak detection devices.
7. Maintain electronic leak detection devices.
8. Describe ultrasonic leak detection.
9. Describe fluorescent dye leak detection.

Evacuation Procedures

1. Describe the operation and application of area monitor systems.
2. Describe the operation of natural gas and carbon monoxide detectors.
3. State the reasons for dehydrating and evacuating refrigeration systems.
4. Use and maintain the following evacuation equipment:

a) access valves
b) electronic vacuum gages
c) evacuation hoses
d) gage manifold
e) single and two stage vacuum pumps and their accessories
f) vacuum pump oils

5. Use triple or deep evacuation according to the Canadian Code of Practice and industry standards.

6. Connect evacuation equipment to a system for quick and effective evacuation.

7. Verify that a system has been properly dehydrated and evacuated.

F. Manual Valves and Accessories ..... 4 Hours

Shut Off Valves

1. Identify the following shut off valves and their applications:
   a) angle
   b) ball
   c) butterfly
   d) compressor service valves
   e) gate
   f) globe

2. Explain where and how the valves listed above should be installed.

Service Access Valves

1. Describe a system access valve and explain the purpose and location of the following valves:
   a) 3-way service
   b) angle
   c) charging
   d) line tap (piercing)
   e) Schraeder

G. Automatic Flow Controls and Applications ..... 8 Hours

Water Regulating Valves

1. Describe the application and operation of water regulating valves (pressure and temperature actuated).

Capillary Tube Systems

1. Describe the operation of the capillary tube as a metering device.

2. Determine the effects of changing ambient conditions on:
   a) condenser sub cooling
   b) capillary tube bubble length
   c) evaporator super heat
   d) compressor amp draw

3. Measure system super heat and sub cooling:
   a) with and without heat exchanger
   b) under low load conditions
   c) under high load conditions
   d) over and under charge conditions

H. Compressor Identification ..... 5 Hours

Identification and Terms

1. Identify the following compressors:
   a) centrifugal
   b) reciprocating
   c) rotary
   d) screw
   e) scroll
2. Define the following terms with reference to compressors:
   a) hermetic
   b) semi-hermetic
   c) open

SECTION TWO: ..... REFRIGERATION AND AIR CONDITIONING THEORY ..... 64 HOURS

A. Refrigeration Industry Introduction ..... 2 Hours

History

1. Describe the history of refrigeration and air conditioning.

Responsibilities

1. Describe the responsibilities of a Refrigeration and Air Conditioning Mechanic.
2. Discuss the Alberta Apprenticeship and Industry Training Act.
3. Describe the Refrigeration and Air Conditioning Mechanic Trade Regulation.

Scope of Work

1. Evaluate the Refrigeration and Air Conditioning Mechanic schedule of work.
2. Describe the scope of the Refrigeration and Air Conditioning industry.
3. Describe refrigeration and air conditioning work in terms of:
   a) maintenance
   b) installation
   c) service and repair
   d) troubleshooting
   e) component selection and system design

B. Relevant Codes and Safety ..... 4 Hours

Refrigeration Code

1. Explain the scope and jurisdiction of the B-52 Mechanical Refrigeration Code.
2. Explain the intent of the different code sections.
3. Explain the scope and jurisdiction of the Canadian Code of Practice.

Related Codes

1. List codes from other trades that affect the work performed by Refrigeration and Air Conditioning Mechanics.

C. Refrigeration Principles and Gas Laws ..... 20 Hours

Fluids and Fluid Systems

1. Define a fluid and the principles of fluid flow within duct and piping systems.
2. Explain the terms velocity, velocity pressure and static pressure.
3. Explain the units used to measure fluid flow.

Gas Laws

1. Describe and apply formulas to solve problems using the following:
   a) Bernoulli's Theorem
   b) Boyle's Law
   c) Charles' Law
   d) combined or general gas law
   e) Dalton's Law
   f) Pascal's Law

Basic Concepts

1. Define the following terms:
   a) energy
   b) force
   c) work
   d) power
2. Perform basic measurements and calculations related to the refrigeration cycle.
3. Define matter and explain the states of matter and their characteristics.
4. Explain how solutions and mixtures apply to the refrigeration cycle.
5. List energy types and forms, and relate these to the refrigeration cycle.
6. Define pressure and differentiate between absolute and gage pressure.
7. Identify the pressure scales used by industry.
8. Convert pressures.
9. Use pressure measuring instruments.

Change of State

1. Explain evaporation, condensation, freezing, melting and sublimation.
2. Describe the effect of pressure on evaporation and freezing temperatures.
3. Define saturated, superheated and subcooled.

Heat and temperature

1. Define:
   a) British Thermal Unit
   b) enthalpy
   c) heat
   d) kilojoule
   e) latent heat
   f) sensible heat
   g) specific heat
   h) temperature
2. Reproduce temperature scales indicating reference points for the following:
   a) Fahrenheit
   b) Rankine
   c) Celsius

d) Kelvin

3. Determine specific heat and British Thermal Unit quantities.

4. Define the following heat transfer methods:
   a) convection
   b) conduction
   c) radiation

5. Give examples of each of the above related to the refrigeration cycle.

6. Convert temperatures between the different scales.

Thermodynamics

1. List and explain the laws of thermodynamics.

2. Determine superheat and subcooling values.

3. Determine quantities of heat transferred.

D. Vapour Compression Cycle and Introduction to Pressure Enthalpy Diagrams ..... 20 Hours

Pressures and Temperatures

1. Describe the operation of a refrigeration system.

2. Use a pressure/temperature chart to determine refrigerant conditions.

3. Measure and record the saturated temperatures and pressures throughout the refrigeration cycle.

4. Measure and record superheating and subcooling throughout the refrigeration cycle.

Refrigeration Effect

1. Define refrigeration.

2. Define refrigeration effect.

3. Explain the operation of the vapour compression cycle.

4. Define the following terms and relate them to their specific section on the vapour compression cycle and the pressure/enthalpy diagram:
   a) compressor (suction) superheat
   b) condenser subcooling
   c) condenser temperature difference
   d) direction of refrigerant flow
   e) evaporator superheat
   f) evaporator temperature difference
   g) high side
   h) low side
   i) pressure drop
   j) saturated discharge pressure
   k) saturated discharge temperature
   l) saturated liquid
   m) saturated suction pressure
   n) saturated suction temperature
   o) saturated vapour
   p) subcooled liquid
   q) superheated vapour
   r) temperature drop
   s) temperature rise

Components

1. Identify the four essential components and connecting piping of the vapour compression cycle.

2. Describe the purpose of the four essential components, the interconnecting piping and the refrigerant fluid.

Cycle of Operation

1. Describe physical changes of the refrigerant as it circulates through the system.
2. Identify the direction and intensity of heat flow.
3. Distinguish between a saturated refrigeration cycle and a real refrigeration cycle.

Capacity

1. Define and explain the application of the following concepts:
   a) condensation
   b) expansion
   c) heat of compression
   d) net refrigeration effect

Application

1. Classify systems according to temperature ranges.
2. Determine the normal operating temperatures and pressures for various systems.

Pressure Enthalpy Diagrams

1. Explain the different parts of a pressure enthalpy diagram.
2. Plot a basic cycle using a pressure enthalpy diagram.
3. Define and determine the following:
   a) mass flow rate
   b) heat of compression
   c) net refrigeration effect
   d) system capacity
   e) ton of refrigeration

E. Refrigerants and Oils ..... 10 Hours

Refrigerant Types and Properties

1. List desirable refrigerant properties.
2. Define the following according to the refrigeration code:
   a) refrigerant
   b) secondary coolant
   c) brine
3. Explain the following in terms of safety and the environment:
   a) azeotrope
   b) blend
   c) chlorofluorocarbon (CFC)
   d) glide
   e) hydrochlorofluorocarbon (HCFC)
   f) hydrofluorocarbon (HFC)
   g) near azeotrope
   h) zeotrope
4. Compare different refrigerants at standard conditions.

Refrigerant Identification

1. Identify refrigerant containers.
2. Identify refrigerants by their colour code.

3. Identify refrigerants in a system.

Refrigerant Handling

1. Safely store and handle refrigerant containers.
2. Safely transfer refrigerants.
3. Define each of the following:
   a) refrigerant recovery
   b) refrigerant reuse
   c) refrigerant recycling
   d) refrigerant reclaiming
   e) refrigerant retrofits

Refrigerant Oils

1. List and explain the functions of refrigeration oil.
2. Apply the correct refrigeration oils to refrigeration systems.
3. Define and explain the significance of the following:
   a) dielectric strength
   b) flash point
   c) floc point
   d) miscibility
   e) pour point
   f) viscosity
4. Describe the following oils and the system each is best suited for:
   a) alkylbenzene
   b) mineral
   c) polyolester

Using Refrigeration Oils

1. Handle and store refrigeration oils correctly and safely.
2. Describe adding, removing, and replacing refrigeration system oil.

F. Air Properties ..... 3 Hours

Properties

1. Describe air and its components.
2. Define the following air properties:
   a) dew point temperature
   b) dry bulb temperature
   c) enthalpy
   d) relative humidity
   e) specific humidity
   f) specific volume
   g) wet bulb temperature
3. List the units and measure the air properties listed above.

G. Customer Relations ..... .4 Hours

Communication

1. Complete sample work orders.

Customer Relations

1. Produce a report detailing proper Refrigeration and Air Conditioning Mechanic customer relations.
2. Communicate effectively using trade terminology.
3. Use word processing software to create above report.

H. Introduction to Blueprint Reading ..... 1 Hour

1. Explain how a standard set of drawings is laid out.
2. Identify each section within a standard set of drawings.
3. Identify standard symbols used with mechanical drawings.

SECTION THREE: ..... HEATING THEORY AND SHOP ..... 16 HOURS

A. Gas Fundamentals and Heating System Components ..... 8 Hours

Safety

1. List and describe safety practices used when working with fuel gases.
2. List the procedures to be followed in the event of a gas leak.

Gas Properties

1. Describe the processing of natural gas with emphasis on the application of refrigeration equipment.
2. Describe the physical and chemical properties of fuel gases.
   a) colour
   b) composition
   c) heating value
   d) ignition temperature
   e) limits of flammability
   f) odour
   g) specific gravity

Gas Pressure and Flow

1. Describe common units to measure fuel gas pressures.
2. List the standard pressure readings taken at gas appliances.
3. Describe the use and operation of manometers and pressure gauges.
4. Use manometers and pressure gauges to measure gas pressures.

B. Gas Burners and Combustion ..... 6 Hours

Gas Burners

1. Identify common types of gas burners and list associated parts.
2. Describe the operation of various types of gas burners.
3. Describe the characteristics of gas flames and adjust gas burners for optimum flame characteristics.
   a) flame roll out
   b) flashback
   c) floating flames
   d) fluctuating flames
   e) lifting flames

f) wavering flames
g) yellow tipping

4. Use gas meters to clock burner gas consumption.

Combustion

1. Describe and define combustion as it relates to fuel gases.
2. Provide and describe the products and effects of complete and incomplete combustion.
3. Calculate volumes of air used in the combustion of fuel gases.
4. Differentiate between complete and incomplete combustion.

C. Relevant Codes ..... 2 Hours

1. Describe Alberta codes and regulations pertaining to the scope of work for Refrigeration and Air Conditioning Mechanics.
2. Describe the scope of the natural gas and propane codes.
3. Define relevant gas code terms.

SECTION FOUR: .....CONTROL THEORY.....32 HOURS

A. Control Fundamentals ..... .20 Hours

Open Loop Control System

1. Refer to a block diagram of an open loop control system and label and define the following:
   a) controller
   b) controlled medium
   c) controlled variable
   d) controlled device
   e) manipulated variable
   f) control agent
2. List industry applications of the open loop control system.

Closed Loop Control System

1. Refer to a block diagram of a closed loop control system and label and define the following:
   a) controller
   b) sensing element
   c) transmitter direct acting and reverse acting
   d) set point
2. Describe controller feedback signals and power sources:
   a) analog signal
   b) digital signal
3. Describe controlled devices:
   a) actuator
   b) final control element
4. Describe control agents:
   a) manipulated variable
5. Discuss process plants.
6. Describe controlled mediums:
   a) controlled variable

b) control point

7. Describe sensor feedback.

8. List several industry applications of the closed loop control system.

9. Describe the operation of the following control systems:
   a) electromechanical
   b) electronic
   c) pneumatic
   d) hybrid
   e) self-contained

10. Define the following with reference to the electromechanical controller:
    a) control point
    b) set point
    c) offset
    d) range
    e) span
    f) differential

Controllers

1. Describe the operation, function and installation of the following EM sensors:
   a) temperature
      i) bimetal strip
      ii) rod and tube
      iii) remote bulb
      iv) averaging element
      v) quick response element
   b) level float
      i) hygroscopic element
   c) humidity
      i) manometer
      ii) pressure bell
      iii) inside/outside bellows
      iv) bordon tube
   d) pressure
      i) velocimeter
      ii) swinging vane
      iii) pitot tube
   e) flow

2. Describe controller transmitters required by each of the following control modes:
   a) on/off and timed on/off
   b) floating
   c) multi-position
   d) modulating

3. Describe the operation of actuators and final control elements in each control mode.

4. Describe the operation, function and construction of the following:
   a) relays
   b) contactors
   c) motor starters
   d) overloads
   e) time delay relays

B. Control Applications ..... 12 HOURS

Electromechanical Control Schematic Reading

1. Recognize all major industry standard electric schematic symbols.

2. Compare a schematic diagram and a connection diagram.

3. Prepare a schematic diagram and connection diagram of a basic domestic heating and air conditioning system.

SECTION FIVE: ..... ELECTRICAL THEORY AND SHOP ..... 48 HOURS

A. Electrical Principles ..... 12 Hours

Fundamentals

1. Define and identify the units of measurement and symbols used for the following:
   a) voltage
   b) current
   c) resistance
   d) impedance
   e) power
   f) energy

2. Describe the effects of low and high voltage.

3. Relate current and power.

4. Relate resistance and power.

5. Define the following:
   a) Ohm's Law
   b) Coloumb's Law
   c) Kirchoff's Current Law
   d) Kirchoff's Voltage Law
   e) Lenz's Law

Methods of Producing Electricity

1. List the five main sources of electricity and describe their applications:
   a) chemical (battery)
   b) piezo-electric
   c) photo-electric
   d) thermo-electric
   e) magnetic induction

Electricity and Magnetism

1. Define the following terminology:
   a) flux
   b) flux density
   c) magnetic field
   d) permeability
   e) reluctance
   f) saturation

2. Describe the difference between temporary and permanent magnets.

3. Explain the Left Hand Rule.

Fundamental Concepts of Alternating Current

1. Explain how alternating current differs from direct current.

2. Define the following alternating current terminal.
   a) peak to peak
   b) RMS (root mean square)
   c) average voltage values
   d) frequency

e) inductance

Basic Circuits

1. Describe the operation of a practical electrical circuit using industrial terminology.
2. Describe the operation of an electrical circuit.
3. State the function of an electrical circuit or system.
4. Describe the function and purpose of each circuit element.
5. Apply the Law of Conservation of Energy to an electrical circuit and each component of the circuit.
6. Determine values of electrical circuit quantities.
7. Explain line drop and its effects.
8. Explain line loss and its effects.
9. Use Kirchhoff's Voltage Law in circuit analysis.
10. Use Kirchhoff's Current Law to explain circuit operation.
11. Calculate voltage, current and resistance values for:
    a) series circuits
    b) parallel circuits
    c) series parallel circuits
12. Compare the operation of loads in series and parallel circuits.
13. Compare the operation of control devices in series and parallel circuits.
14. Identify direct current, single phase and three phase alternating current systems.

Electrical Circuit and Component Testing

1. List test meters and instruments.
2. Describe the characteristics, precautions for use and limitations of test meters and instruments.
3. Use a voltmeter, ammeter and ohmmeter.
4. Define continuity.
5. Check continuity of a circuit.
6. Verify circuit operation with electrical measuring instruments.
7. Identify electrical shorts and open circuits using an ohmmeter.
8. Notify appropriate personnel of electrical hazards and potential ground fault hazards.

B. Electrical Equipment..... 10 Hours

Components

1. Describe circuit components, their characteristics and factors affecting use and care.
2. Identify the components in a practical circuit.
3. Classify electrical components by their circuit function.
4. Determine ratings for each component of a circuit.
5. Test insulation with a megger.
6. Define temperature rise.
7. List signs of high temperature and its effects.
8. List causes of abnormally high temperature.

C. Circuits and Systems ..... 10 Hours

1. Describe electrical specifications and diagrams used in the refrigeration industry.
2. Follow a single line diagram of an electrical system.
3. Draw and connect elementary relay boards.
4. Use introductory troubleshooting skills to identify faulty components.

D. Relays and Contactors..... 8 Hours

1. Describe relay and contactor operation.
2. List the ratings for a relay and for a contactor.
3. Identify and draw relay symbols.
4. Apply basic relay and actuator fundamentals.

E. Electrical Safety ..... 8 Hours

1. Define over-current.
2. Define overload.
3. Identify protective devices.
4. Identify cap/receptacle configurations.
5. Use cords approved for the application.
6. Make an extension, start cord and continuity tester.
7. Make approved connections, terminations or splices.
8. Identify and define a grounded circuit.
9. Identify and define isolated circuit or system.
10. Describe the purpose of a ground fault interrupter.
11. State reasons why grounded circuit conductors should not contain protective or control devices.
12. Describe the operation of a GFCI.
13. Maintain a safe working environment.
14. Demonstrate safe working practices.
15. List reasons for keeping electrical equipment and work areas clean and dry.
16. List specific types of equipment noises, possible problems and remedies.
17. Identify proper lock out procedures.

SECOND PERIOD TECHNICAL TRAINING
REFRIGERATION AND AIR CONDITIONING MECHANIC TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS COURSE THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES:

Due to the nature of the work of the Refrigeration and Air Conditioning Mechanic, it is imperative that safety be emphasized throughout this course.

Special emphasis should be placed on weak areas of theory and lab that are evident from progressive tests and examinations administered throughout the course. The time required for such examinations and testing shall be allowed for in each area of instruction.

SECTION ONE: ..... REFRIGERATION AND AIR CONDITIONING SHOP .....80 HOURS

A. Evaporator Feed Controls ..... 12 Hours

Basic Refrigeration Metering

1. Describe the purpose of the evaporator feed control in a refrigeration system.

Types and Operation

1. Describe the construction, installation and operation of the following metering devices:
   a) automatic expansion valve
   b) capillary tube
   c) electronic expansion valve
   d) floats
   e) hand expansion valve
   f) restrictors
   g) thermostatic expansion valve
2. Compare the operation of metering devices in terms of the following:
   a) refrigerant charge
   b) system application (direct expansion, flooded, liquid overfeed)
   c) responsiveness to load variations

Expansion Valves

1. Explain the system operation and control characteristics of the following expansion valves:
   a) hand expansion valve
   b) automatic expansion valve
   c) thermostatic expansion valve

Thermostatic Expansion Valve

1. Define the following thermostatic expansion valve terms:
   a) constant superheat
   b) hunting
   c) starving or flooding
   d) tonnage capacity
2. Compare thermostatic expansion valves based on:
   a) bulb charges
   b) bulb responsiveness
   c) equalization (external or internal)
   d) operating temperature range
   e) temperature

3. List the types of distributors and explain their applications.
4. Select and install thermostatic expansion valves.
5. Troubleshoot and service thermostatic expansion valves.
6. Describe the operation and application of pressure limiting thermostatic expansion valves.
7. Explain the methods of checking and adjusting the thermostatic expansion valves on single or a multiple circuited evaporators.
8. Explain nominal tonnage rating of thermostatic expansion valves.
9. Explain variables that affect thermostatic expansion valve capacity.
10. Select thermostatic expansion valves for various applications.

Installation and Service

1. Determine the proper metering device for various applications.
2. Install, service and adjust expansion valves.
3. Explain glide in terms of superheat measurement and adjustment.
4. Troubleshoot expansion valves during the following problem conditions:
   a) high load conditions
   b) low load conditions
   c) refrigerant overcharge
   d) refrigerant undercharge
5. Describe the installing and servicing of electronic expansion valves.
6. Describe the servicing and adjusting of low and high side floats.

B. Hermetic Compressors and Circuit Components ..... 14 Hours

Hermetic and Semi-hermetic Compressors

1. Describe the four types of single phase hermetic motors, their components and operating characteristics.
2. Identify and test the electrical windings at the terminals on various single phase motors.
3. Explain hermetic compressor motor cooling.
4. Demonstrate the starting principles of single phase motors.
5. Compare the relative starting torques of the four types of motors.
6. Classify compressors according to temperature ranges.

Motor Starting Relays

1. Check and replace a current relay.
2. Check and replace a potential relay.
3. Demonstrate the construction and operation of solid state motor starting relays.
4. Demonstrate how to improve motor starting torque.

Motor Control Components

1. Demonstrate the construction and operation of run capacitors used with hermetic refrigeration motors.
2. Demonstrate start capacitor construction and operation when used with hermetic refrigeration motors.
3. Apply the following capacitor terms with reference to:
   a) applied voltage
   b) bleed resistor

c) capacitor bank
d) identified terminal
c) microfarad
d) voltage rating

4. List and check capacitor faults.

Motor Protection

1. List operating principles of overload and over-current devices.
2. Distinguish between inherent and non-inherent line and pilot duty.
3. Sketch and explain overload operation and service.

Motor Failures

1. Define hermetic motor burnout and distinguish between severe and moderate burnouts following inspection and acid testing.
2. List the causes of motor burnout.
3. Describe the industry standard burnout cleanup.

Service

1. Distinguish the following hermetic compressor problems:
   a) electrical
   b) mechanical
2. Correct electrical and mechanical hermetic compressor problems.

C. Automatic Flow Controls and Applications ..... 10 Hours

Automatic Regulators

1. Describe the operation, application and service of the following:
   a) check valves
   b) diverting valves
   c) gas powered stop valves
   d) heat reclaim valves
   e) mixing valves
   f) reversing valves (heat pump valves)
   g) slide valves
   h) solenoid valves
2. Describe the operation, application and service of the following:
   a) crankcase pressure regulator
   b) differential pressure regulator
   c) evaporator pressure regulator
   d) flooding control
   e) head pressure control
   f) hot gas bypass regulator

D. Refrigeration Accessories ..... 6 Hours

1. Describe the operation, application and service of the following accessories:
   a) accumulator
   b) discharge muffler
   c) liquid line filter/drier
   d) oil separator
   e) sight glass
   f) solenoid valve

g) suction filter
h) suction-to-liquid heat exchanger

2. Install, wire and check the operation of an oil failure control.

3. Troubleshoot an oil failure control system.

E. Service Refrigeration Systems ..... 24 Hours

Selecting and Locating Equipment

1. Describe the proper method of mounting condensing units and evaporators.

Installing Components

1. Describe the proper method of connecting suction and liquid lines with supplied piping and materials.
2. Compare the use of copper and steel pipe.
3. Compare the use of copper and steel fittings.
4. Describe the proper method of installing filter, driers, metering devices and solenoid valves.
5. Draw an electrical schematic diagram complete with legend.
6. Draw piping schematic diagram complete with legend.
7. Wire components.

Leak Test, Evacuate and Charge

1. Leak test system using approved methods.
2. Evacuate system using approved methods.
3. Properly charge system and adjust controls for normal operation.
4. Operate system, check and adjust evaporator superheat.

Report

1. Check and record all control settings.
2. Check and record fixture temperature.
3. Check and record all system operating temperatures and pressures.

F. System Troubleshooting ..... 8 Hours

1. Describe the following hermetic compressor problems:
   a) electrical
   b) mechanical
2. Perform electrical checks on single phase compressor motors:
   a) diagnose grounded windings
   b) diagnose open windings
   c) diagnose high resistance windings
   d) diagnose shorted windings (turn-to-turn and winding-to-winding)
   e) diagnose open internal overloads
   f) diagnose high resistance and intermittent shorts to ground
3. Explain mechanical failures due to:
   a) loss of lubrication
   b) flooding
   c) flooded starts
   d) slugging
   e) hydraulic compression

f) overheating
g) short-cycling

G. Retrofiting And Conversions. ..... 6 Hours

Refrigerant Recovery

1. Set up recovery unit.
2. Prepare system and equipment for refrigerant removal.
3. Remove refrigerant from system.

Oil Removal and System Clean-up

1. Remove and measure oil charge using an oil pump.
2. Install clean-up filter/driers.
3. Leak check system.
4. Evacuate system.
5. Replace oil charge.
6. Charge system with new refrigerant.

System Startup and Component Setup

1. Install temperature sensors and ammeter.
2. Start up system.
3. Adjust refrigerant charge and operating components.
4. Record operating temperatures, pressures and amperage.
5. Perform system pump-down.
6. Take oil sample and analyze.
7. Remove and replace oil charge if necessary.
8. Return system to operation.

SECTION TWO:..... REFRIGERATION AND AIR CONDITIONING THEORY .....64 HOURS

A. Refrigeration Effect..... 4 Hours

Producing the Refrigeration Effect

1. Define refrigeration effect.
2. List the methods of producing the refrigeration effect.
3. Describe and provide a practical application for each of the following refrigeration processes:
   a) evaporating a liquid
   b) expanding a gas
   c) melting a solid
   d) peltier effect
   e) vortex tube

Absorption Cycle

1. Describe the absorption cycle.
2. Differentiate between domestic and commercial absorption cycles.

3. Identify the components and principle of operation of an ammonia and water absorption system.

4. Identify the components and state the principle of operation of a lithium bromide system.

Evaporative Cooling

1. Describe the evaporative cooling process.

2. Describe the installation, service and repair of evaporative coolers.

B. Compressors ..... 8 Hours

Compressor Components

1. Define and describe the following compressor components:
   a) crankshaft
   b) discharge and suction valves and valve plates
   c) fixed and orbital scrolls of a scroll compressor
   d) impellers and discharge volute
   e) internal relief valves
   f) piston assemblies
   g) rotary compressor blades and vanes
   h) Scotch yoke
   i) screw compressor rotors

Compressor Operation and Capacity

1. Describe the compression processes, including valves and valves operations, of a reciprocating compressor.

2. Explain the compression process of other compressor types.

3. Describe the flow of gas through the compressor.

4. Describe splash and forced lubrication systems and include:
   a) crankcase vent
   b) magnetic plug
   c) oil check valve
   d) oil cooler
   e) oil pressure measurement
   f) oil pump
   g) oil relief valve
   h) oil suction screen

Lubrication and Cooling

1. Describe oil circulation and control throughout a system.

2. Explain the operation of oil failure controls, including mechanical and electronic types.

3. Install, wire and check the operation of an oil failure control.

Capacity Control

1. Describe the following capacity control systems:
   a) cylinder bypass
   b) cylinder unloading
   c) hot gas bypass
   d) inlet vanes (centrifugal)
   e) multiple compressors
   f) slide valve (screw)
   g) suction stop
   h) variable clearance volume
   i) variable speed

2. Describe cylinder unloading mechanisms.

3. Explain nominal capacity of compressors.
4. Explain how manufacturers rate compressor capacity.
5. List and describe variables that affect compressor capacity and efficiency.
6. Explain how compressor efficiency is maximized.
7. Define compressor pumping in terms of the following:
   a) compression ratio
   b) compressor efficiency
   c) actual displacement
   d) theoretical displacement

C. Evaporators and Condensers ..... 6 Hours

Types and Components

1. Classify evaporators according to:
   a) circuits and passes
   b) counter, cross and parallel flow
   c) direct expansion, flooded and liquid overfeed
   d) fins and fin spacing
   e) forced and induced
   f) plate or eutectic
   g) primary and secondary surface
2. Describe evaporators used in each of the following applications:
   a) air coolers
   b) air driers
   c) ice makers
   d) water and brine chillers
3. Describe evaporators that use the following defrost methods:
   a) electric
   b) latent heat (hot gas)
   c) reverse flow
4. Describe the components of direct expansion and flooded chillers.
5. Describe drain pan heaters and evaporator fan control for walk-in freezers.
6. Classify condensers according to the following configurations:
   a) air or water cooled
   b) circuits and passes
   c) fins and fin spacing
   d) plate
   e) primary and secondary surface
   f) shell and coil
   g) shell and tube
   h) tube and tube
7. Explain the effect of the following on the capacity and efficiency of evaporators and condensers:
   a) air or water velocity
   b) counter flow versus parallel flow
   c) evaporator temperature difference
   d) frost accumulation
   e) number of circuits
   f) number of passes
   g) oil circulation
   h) refrigerant pressure loss
   i) refrigerant velocity
   j) evaporator superheat
   k) surface wetting

l) thick versus thin coils

Capacities and Applications

1. Describe evaporator and condenser capacity rating.
2. Describe condenser function in terms of:
   a) condensing
   b) desuperheating
   c) subcooling
3. Identify air cooling evaporators and water chillers in industry catalogues.
4. Identify air cooled condensers and water cooled condensers in industry catalogues.

Installation and Service

1. Describe the service and repair of evaporators and condensers:
   a) describe descaling
   b) describe retubing

D. Evaporative Condensers and Cooling Towers ..... 5 Hours

Components and Operation

1. State the heat rejection principle used by cooling towers and evaporative condensers.
2. Label and describe the components of an evaporative condenser.
3. Label and describe the components of a cooling tower.
4. Describe the differences between spray filled and splash deck towers.
5. Describe the following:
   a) natural draft tower
   b) forced draft tower
   c) induced draft tower
6. Discuss the water cooled condenser circuit:
   a) when used with a water tower
   b) when used with a city waste water system
7. Describe the differences between water tower and city waste water systems.
8. Draw a diagram to illustrate a closed circuit water cooler.
9. List three advantages of a closed circuit cooling tower.
10. Describe a dry cooler.
11. State the advantages of dry coolers in cold climates.

Start Up and Control

1. Explain head pressure management by controlling cooling towers, heat rejection rate, evaporative condensers and evaporation rate.
2. Explain the application of a cooling tower and an evaporative condenser in a cold climate.
3. Describe and determine the capacity of a cooling tower and an evaporative condenser using psychrometric processes.
4. Explain the purpose of a condenser by-pass and a tower by-pass on a cooling tower system.
5. Define the term “approach” as it applies to cooling towers.
6. Define the term “range” as it applies to cooling towers.
7. Describe the seasonal maintenance for evaporative condensers and cooling towers.

8. State the installation of an evaporative condenser and a cooling tower.

Maintenance and Water Treatment

1. List and describe a cure for each of the following water problems:
   a) algae, slime and bacteria
   b) corrosion
   c) dirt and debris
   d) scaling

2. Describe the following mineral concentration control methods for cooling towers and evaporative condensers:
   a) bleed off
   b) descalers
   c) water treatment

E. System Analysis..... 32 Hours

Pressure-enthalpy Diagram

1. Describe the properties of a pressure-enthalpy diagram.

2. Identify the following areas of the diagram:
   a) liquid
   b) saturation
   c) vapour

3. Locate and identify temperature and pressure points of a cycle on a pressure-enthalpy diagram.

4. Graph saturated and real refrigeration cycles.

5. Use a pressure-enthalpy diagram to create a report that contains a basic refrigeration cycle and includes the following:
   a) all system values
   b) all refrigerant properties
   c) all processes

System Thermodynamics

1. Determine system capacity.

2. Determine system efficiency.

3. Calculate the following using supplied data:
   a) actual displacement
   b) brake horsepower
   c) coefficient of performance
   d) compression ratio
   e) condenser heat of rejection
   f) de-superheating
   g) heat of compression
   h) mass flow rate
   i) net refrigeration effect
   j) subcooling
   k) superheating
   l) system capacity
   m) theoretical displacement
   n) theoretical horsepower
   o) total heat rejected from the condenser
   p) total heat rejected from the system

4. Explain and calculate theoretical horsepower and brake horsepower and describe the differences between the two concepts.

5. Determine pressure looses in refrigerant piping.

6. Describe the affects on system capacity resulting from:
   a) changes in saturated discharge temperature
   b) changes in saturated suction temperature
   c) liquid subcooling
   d) suction superheating
   e) suction to liquid heat exchanger
   f) high and low side pressure drops

System Balancing

1. Balance a compressor and evaporator.
2. Total system balance.

Pressure-enthalpy Diagram as a Troubleshooting Aid

1. Apply cycle diagrams to assist in troubleshooting the following:
   a) loss of refrigerant
   b) overcharge of refrigerant
   c) undercharge of refrigerant
   d) partially restricted metering device
   e) fully restricted metering device
   f) dirty filter drier
   g) moisture in system
   h) non-condensables in system
   i) dirt on coils
   j) bent or damaged tubing

Troubleshooting

1. Explain the difference between a systematic check-out procedure and the art of troubleshooting.
2. Describe the troubleshooting procedure.
3. Read and interpret troubleshooting charts.

F. Relevant Codes ..... 3 Hours

Refrigeration Code

1. Describe significant refrigeration terms using the B-52 Mechanical Refrigeration Code.

Related Codes and Standards

1. Interpret and apply Environment Canada's "Code of Practice for the Reduction of Chlorofluorocarbon Emissions from Refrigeration and Air Conditioning Systems".
2. Apply relevant refrigeration and air conditioning standards.

G. Air Conditioning Fundamentals ..... 4 Hours

1. Identify new refrigerants used for air conditioning.
2. List the components of a split air conditioning system.
3. describe the major components of a single stage package roof top air conditioning unit.

H. Blueprint Analysis ..... 2 Hours

1. Define divisions of blueprints.
2. Read and interpret basic mechanical specifications.
3. Identify refrigeration and air conditioning components from a simple set of mechanical drawings.

SECTION THREE: ..... HEATING THEORY AND SHOP ..... 32 HOURS

A. Gas Orifices and Pilot Devices ..... 8 Hours

Gas Orifices

1. Describe the following common types of orifices used in gas burners:
   a) continuous
   b) intermittent
   c) interrupted
   d) aerated
   e) non-aerated
   f) incinerating
   g) target
2. Read and interpret orifice sizing tables.
3. Determine orifice sizing requirements for changes in altitude.

Pilot Burners

1. Identify the common types of pilot burners.
2. Describe the operation of pilot burners.
3. List and describe pilot flame characteristics.
4. Adjust pilot burners and troubleshoot common pilot burner problems.

B. Basic Gas Control Systems ..... 12 Hours

Thermocouples and Thermopiles

1. Describe the operation of thermocouples and thermopiles.
   a) components
   b) flame failure response time
   c) operating voltages
   d) pilot generator
   e) pilotstat coil
   f) pilotstat valve
2. List the common types of pilot safety controls.
3. Describe methods and tests used to determine the condition of thermocouples and thermopiles.
4. Test system components and diagnose basic gas thermocouple and thermopile problems.

Gas Valves

1. Describe the following gas valves:
   a) bimetallic
   b) diaphragm
   c) modulating
   d) redundant

e) solenoid
f) two stage

2. Describe how a 100% shut off valve differs from a non-100% shut off valve.

Basic Gas Control System Components

1. Identify the components of a basic heating and cooling appliance control system.
2. Describe the operation of basic heating and cooling appliance control system.
3. Describe methods and tests used to determine the condition of basic heating controls.
4. Test system components and diagnose basic heating controls.

C. Air Supply and Venting ..... 12 Hours

Air Supply

1. State the general air supply requirements for gas appliances.
2. Describe the location and sizing of air supply ducts.
3. Calculate volumes of air used in a gas appliance operation.

General Venting

1. Describe the operation of an atmospheric venting system.
2. List the basic material and location requirements of atmospheric venting systems.
3. Define air supply according to code.
4. Label the components of a vent system and distinguish between type 'A', 'B' and 'C' vents.
5. List two major factors that affect venting power.
6. Describe vent problems such as spillage and condensation.
7. Explain down drafts, overloading and over firing.
8. Describe air supply requirements for gas heating appliances under 400,000 BTU/H input.
9. List functions of a draft hood or draft diverter.
10. Explain the operation of an automatic vent damper system.
11. Describe power ventors.
12. Describe the sequence of operation of an automatic vent damper control system.

SECTION FOUR: ..... CONTROL SYSTEMS THEORY AND SHOP ..... 32 HOURS

A. Control Systems ..... 32 Hours

Diagnose System Faults

1. Discuss the function, operation, construction and installation of the following electromechanical circuit components:
   a) control relays
   b) contactors and starters
   c) solenoid valves
   d). isolation transformers
   e) overloads and fuses
   f) timers
   g) time delay relays

h) pressure controls
i) oil failure controls
j) thermostatic controls
k) diaphragm switches
i) centrifugal switches

2. Demonstrate problem solving techniques, using a schematic diagram, on an actual or simulated electromechanical heat/cool control circuit. Problems shall include:
   a) shorted capacitor
   b) open relay coil winding
   c) open motor winding
   d) burned relay contact points
   e) refrigerant leak
   f) short circuit

3. Compare control circuits for the following control systems:
   a) solenoid drop
   b) pump down
   c) pump out
   d) X-terminated defrost timers
   e) off-cycle defrost

Simple Unitary Electronic Control Systems

1. Discuss the construction, function and operation of the following semi-conductors:
   a) diode
   b) transistor
   c) SCR
   d) VDR

2. Discuss the construction, function and operation of the following electronic sensors:
   a) hygroscopic
   b) thermistor
   c) RTD
   d) hall effect sensor
   e) photo transistor
   f) flame rectifier

3. Solve Modified Wheatstone Bridge balancing problems.

4. Identify the components of a DC power supply on an electrical schematic and discuss the function of each component.

5. Describe the construction, function and operation of a Modified Wheatstone Bridge control circuit.

Hybrid Electromechanical and Electronic Control System Operations

Control Valve Identification

Valve Designs

1. Describe valve design characteristics and include:
   a) flow characteristics
   b) travel coefficient
   c) rangeability
   d) capacity index
   e) valve body rating
   f) nominal body rating

Identify Dampers by Function and Design Characteristics

SECTION FIVE: ..... ELECTRICAL THEORY AND SHOP ..... 32 HOURS

A. Transformers ..... 2 Hours

1. Describe the three main types of transformers:
   a) autotransformers
   b) current transformers
   c) isolation transformers
2. List the main components of a transformer.
3. Based on the principle of mutual inductance explain the operation of a transformer.
4. Explain the relationship between turns, current and voltage.
5. Calculate secondary and primary volt amp rating (VA).
6. Describe the reasons for transformers in series and parallel.
7. Describe the difference between step-up and step-down transformers.
8. Explain transformer ratings.
9. Explain the purpose and use of multi-tap transformers.
10. Explain the operation and purpose of an isolation transformer.
11. Identify a class 2 transformer and its characteristics.

B. Motors ..... 16 Hours

Mechanical Characteristics

1. Define the following terms:
   a) horsepower
   b) brake horsepower
   c) synchronous speed
   d) slip
2. Calculate the horsepower rating of a motor.
3. Describe the relationship between speed, torque and horsepower.
4. Explain the various types of motor enclosures:
   a) general
   b) guarded
   c) drip-proof
   d) splash proof
   e) non-ventilated
   f) explosion proof
   g) water proof
5. List and explain the specifications of a motor nameplate:
   a) frame size
   b) horsepower rating
   c) duty cycles
   d) phase rating
   e) speed
   f) frequency
   g) voltages
   h) current ratings

i) ambient temperatures
j) service factor ratings

6. Describe the construction of an electric motor and identify each of the following parts:
   a) rotor
   b) stator
   c) windings
   d) stator poles
   e) overload
   f) centrifugal switch
   g) bearings
      i) sleeve
      ii) ball

7. Describe proper greasing methods.

Electrical Characteristics

1. Define the following alternating current terminology:
   a) inductance
   b) inductive reactance
   c) mutual inductance
   d) capacitive reactance

2. Describe the phase relationship between current and voltage in inductive and capacitance circuits.

3. Describe true and apparent power.

4. Calculate power factor.

5. Identify the operation and applications of single phase motors including:
   a) capacitor start
   b) capacitor start and run
   c) permanent split capacitor
   d) resistance start
   e) shaded pole motors
   f) capacitor ratings and applications
   g) internal protection

6. Capacitors:
   a) describe the basic structure of a capacitor
   b) explain electron flow in a capacitor
   c) calculate the values of capacitors in both series and parallel circuits
   d) define capacitor ratings in reference to MFD and voltage.

7. Connect split phase motors.

8. Identify and troubleshoot single phase motors.

9. Reverse a split phase motor.

10. Identify single phase motor winding failure.

11. Describe the operation of starting switches.

12. Describe the difference between a multi-speed and a multi-horsepower motor.

13. Describe the wiring configuration for both high and low voltage

14. Describe how to change rotation on a single phase motors.

15. Describe three phase motor fundamentals and basic wiring.

Motor Circuits

1. Identify the components and functions of a motor circuit using industrial terminology:
   a) size or set the overload protection based on manufacturers specifications
   b) describe and provide an example of auto rese
   c) describe and provide an example of manual rese
2. Describe the operation of common motor control circuits used in industry.
3. Motor protection devices
   a) stator stats
   b) overloads
   c) thermal protection
   d) inherent protection

C. Troubleshooting Electrical Problems.....5 Hours

1. Describe normal circuit operation:
   a) list basic components of an electrical circuit and the name plate ratings for each component
   b) use analogue and digital voltmeters to identify circuit and component conditions
2. Interpret schematic and wiring diagrams.
3. Analyze abnormal circuit conditions:
   a) open circuit
   b) short circuit
   c) overload
   d) ground fault
   e) use analogue and digital voltmeters to identify circuit conditions and component conditions
4. Determine when to consult with an electrician.
5. Determine electrical equipment wear, the causes and the effects.
6. Describe the principles of single phasing of a three-phase motor.

D. Basic Electrical Code..... 1 Hour

1. Identify Class 1 and 2 transformers.
2. Identify CEC Code requirements for hermetic compressors.

THIRD PERIOD TECHNICAL TRAINING
REFRIGERATION AND AIR CONDITIONING MECHANIC TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS COURSE THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

Due to the nature of the work of the Refrigeration and Air Conditioning Mechanic, it is imperative that safety be emphasized throughout this course.

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SECTION ONE: ..... REFRIGERATION AND AIR CONDITIONING SHOP ..... 72 HOURS

A. Defrosting ..... 10 Hours

Defrost Methods

1. Describe methods of electric defrost and gas defrost using the following:
   a) conventional gas flow
   b) reverse cycle gas flow
   c) two-pipe
   d) reverse flow
2. Describe the importance of preventing liquid from returning to the compressor during gas defrost.
3. Describe the methods used to prevent liquid from returning to the compressor during gas defrost and the use of:
   a) suction accumulators
   b) re-evaporator coils
   c) vaporizers
4. Describe the use of timed-off and off-cycle defrost.

Defrost Circuits and Components

1. Describe electric defrost circuitry, including:
   a) defrost components
   b) defrost initiation
   c) defrost termination
   d) demand defrost
   e) fan delay
2. Describe gas defrost circuitry (the piping circuit for both single and multiple evaporator systems) include all defrost components and their control.
3. Describe the application of dual evaporator pressure regulators to promote gas defrost for multiple evaporator systems using conventional hot gas defrost.

Installation and Troubleshooting

1. Install gas and electric defrost systems.
2. Troubleshoot and service defrost systems.

B. Ice Cubers and Flakers ..... 4 Hours

Types and Operation

1. Describe the operation of a commercial ice cuber and flaker.

2. Describe the operation of an industrial ice flaker.
3. Describe harvest methods.

Installation

1. Install and start up a commercial ice flaker.
2. Install and start up a commercial ice cuber.

Service

1. Read cuber and flaker schematic diagrams.
2. Troubleshoot and service cubers and flakers.

C. Advanced Installation of Refrigeration Systems ..... 42 Hours

Selecting and Locating

1. Draw an electrical schematic for the refrigeration system and include the following:
   a) cycling controls
   b) distribution lines for control and power circuits
   c) major system components
   d) operating controls
   e) power sources
   f) safety controls
2. State the factors that determine the optimum location of evaporators and condensers.
3. Select refrigerants for specific applications.
4. Draw a piping schematic that includes the following:
   a) isolation valves
   b) major components
   c) piping and fittings
   d) controls and accessories
   e) safety devices
5. Create a complete bill of materials.

Installing Components

1. Describe the installation of evaporators.
2. Describe the installation of condensing units and condensers.
3. Connect suction and liquid lines with supplied piping and materials.
4. Install filter/driers, metering devices, solenoid valves and other flow controls and accessories.
5. Use acceptable piping practices and apply installation requirements according to code.
6. Insulate refrigeration lines.
7. Install operating and safety controls.
8. Wire all controls and components.

System Processing

1. Leak test the system using approved methods.
2. Evacuate the system using approved methods.
3. Charge the system with refrigerant.
4. Adjust the operating and safety controls.

5. Start the system and check the following:
   a) compressor amperage
   b) refrigerant charge
   c) oil levels
   e) superheats (evaporator and compressor)
   f) discharge temperature
   g) cabinet temperatures

6. Check and adjust all flow controls.

Fine Tuning System

1. Create a compressor/evaporator balance graph, read and evaluate the results, and adjust the controls as required.

2. Measure and plot a pressure enthalpy cycle diagram of the operating system and read and evaluate the results.

Refrigerant Recovery and Reuse

1. Shut down system, recover and recycle refrigerant.

2. Explain the process of returning recovered refrigerant to the original manufacture for reclaim.

Report

1. Write a report detailing how the installation was managed and include the following:
   a) project objective
   b) equipment list
   c) schematics and drawings
   d) sizing and selection calculations
   e) refrigerant used
   f) balance graphs and charts
   g) system test results
   h) disposition of recovered refrigerants and hazardous wastes
   i) summary of the complete installation and shutdown

D. Compressor Maintenance and Overhaul ..... 8 Hours

1. Disassemble a compressor and inspect the internal parts for wear.
2. Provide a report on failed compressors.
3. Describe how to overhaul reciprocating compressors and components.
4. Read manufacturer's compressor specifications.

E. Troubleshooting Advanced Refrigeration Systems ..... 8 Hours

1. Install both mechanical and electrical faults into the completed project.
2. Troubleshoot and repair projects as prescribed.
3. Write a service report about problems and required repairs.

SECTION TWO: ..... REFRIGERATION AND AIR CONDITIONING THEORY ..... 48 HOURS

A. Refrigeration System and Component Design ..... 14 Hours

System and Component Capacity

1. Describe the capacity rating of the major components.

2. Compare and explain the required horsepower per ton of an air conditioning system to the required horsepower per ton of a low temperature system.
3. List the variables affecting field installed systems and component capacities.
4. Describe how to maximize capacities and efficiencies of field installed equipment.

Evaporator and Compressor Balance

1. Select refrigeration compressors and condensing units.
2. Select evaporators and condensers (air and water cooled) for refrigeration applications.
3. Graphically analyze data for the following refrigeration system components:
   a) compressor
   b) multiple compressors
   c) compressors with cylinder unloading
   d) evaporator
   e) multiple evaporators operating at the same and different temperatures
4. Determine the following after graphing evaporator and compressor data on a saturated suction temperature/capacity graph:
   a) balance point
   b) system temperature penalty
   c) operating saturated suction temperature
   d) operating evaporator temperature difference
   e) cabinet relative humidity
   f) system operating capacity

Condenser Capacities

1. Select an air cooled condenser for a given temperature difference using the heat rejection factors and/or a pressure-enthalpy diagram.

Thermostatic Expansion Valve Capacities

1. Select a thermostatic expansion valve for a given system.

Water Cooled Condensers

1. Select a water cooled condenser for a given system.

Accessories

1. Select the following accessories:
   a) liquid line filter/drier and sight glass
   b) suction line drier
   c) liquid line solenoid valve

B. Refrigeration and Air Conditioning Load Calculations ..... 8 Hours

Heat Quantities and Flow

1. Express heat transfer factors.
2. Define refrigeration load.
3. Compare the short and long methods of load estimating.
4. List the four major sources of heat leakage into a refrigerated fixture.
5. Determine heat transfer rates and resistance using K, C, U and R values.

Refrigeration Loads

1. Determine refrigeration loads using computer software.
2. Use quick selection tables to determine a refrigeration load.
3. Calculate heat transmission loads for refrigerated fixtures above and below 32°F.
4. Calculate air infiltration loads for refrigerated fixtures above and below 32°F.
5. Calculate product loads for refrigerated fixtures above and below 32°F.
6. Calculate miscellaneous loads for refrigerated fixtures above and below 32°F.
7. Calculate total loads and the running times for refrigerated fixtures above and below 32°F.

C. Food Preservation..... 2 Hours

Foods and Food Spoilage

1. List factors that determine food quality.
2. List the causes of food spoilage.
3. Explain the correct temperatures, humidities, air circulation and food storage for optimum shelf life and efficient energy use.

Methods of Food Preservation

1. Describe methods of food preservation.

Refrigerated and Frozen Food Storage

1 Explain how the refrigeration process preserves food.
2. Explain the freezing process.
3. Read and interpret product storage data to determine optimum food storage conditions.
4. Describe the harvesting and preparation of fruits and vegetables by refrigeration and freezing.
5. Describe the preparation of meat and poultry products for refrigeration and freezing.
6. List factors that optimize storage of refrigerated and frozen foods.

D. Piping Design and Practices ..... 12 Hours

Piping Materials

1. Describe the piping materials used in refrigeration systems.
2. Describe pipe measurement for both copper and steel piping.
3. Describe pipe joining methods:
   a) compression
   b) flange
   c) flare
   d) pipe
   e) sweat
4. Describe suction, liquid, discharge and condensate lines with respect to the following:
   a) acceptable fluid velocities
   b) acceptable pressure losses
   c) oil circulation
   d) refrigerant circulation

Piping practices

1. Describe piping practices in respect to the following piping sections:
   a) condensate line
   b) discharge line
   c) liquid line
   d) suction line
2. Cut the required pipe length given a center-to-center measurement.
3. Construct piping offsets by applying set, run and travel measurements.

Design of Piping Systems

1. Define temperature penalty.
2. List acceptable refrigeration system temperature penalties.
3. Determine acceptable system pressure loss.
4. Determine equivalent pipe lengths for fittings and valves.
5. State the primary factors to be considered in sizing and installing refrigerant lines.
6. Determine refrigerant pressure losses and velocities from tables.
7. Select copper suction and liquid lines for refrigeration systems.
8. Explain when, why and how double suction and discharge risers are used.

Troubleshooting Refrigeration

1. List, describe and correct piping problems.

E. Industrial Systems ..... 8 Hours

Flooded and Overfeed Systems

1. List advantages and disadvantages of each of the following industrial systems:
   a) liquid overfeed
   b) flooded
   c) direct expansion
2. Compare liquid overfeed systems to flooded and direct expansion systems.
3. List and describe the components of liquid overfeed systems.
4. Describe the operation and control of a single stage, liquid overfeed system equipped with a circulation pump and include the following:
   a) float switch
   b) hand expansion valve
   c) low pressure receiver
   d) wet return lines
5. List and describe the components, operation and control of liquid overfeed systems.
6. Graphically analyze the thermodynamics of an ammonia, liquid overfeed system using a pressure enthalpy diagram.
7. Explain the types, operation and service of purge systems.

Helical Screw Compressors

1. Compare screw compressors to reciprocating compressors.
2. List the components, explain the operation and describe the control of a screw compressor system. Include the following:
   a) capacity control

b) compression process
c) methods of compressor cooling
d) methods of lubrication
e) thrust balance piston
f) variable volume ratio

3. Describe the servicing of a screw compressor system.

F. Relevant Codes ..... 4 Hours

1. Review the installation section of the B-52 Mechanical Refrigeration Code.
2. Review changes to the Canadian Code of Practice.

SECTION THREE: ..... HEATING THEORY AND SHOP ..... 32 HOURS

A. Relevant Codes ..... 2 Hours

Gas Codes

1. Describe gas code requirements related to gas appliance venting.

B. Electronic Ignition Systems ..... 24 Hours

Ignition Systems

1. Describe the following gas appliance systems and their components:
   a) bimetal system
   b) liquid filled system
   c) glow coil system
   d) other ignition systems

Appliance Tests

1. Explain the purpose of a pilot turn down test.
2. Perform a pilot turn down test.
3. Test for safety shut down.
4. Check for a leaking heat exchanger.
5. List and explain the factors that determine appliance efficiency.
6. Determine appliance efficiency using the temperature rise method.

Condensing Heating Systems

1. Describe the operation of a condensing heating appliance.
2. Troubleshoot a condensing heating system.

Electronic Proven Pilot Systems

1. Explain the operation of each component of an electronic proven pilot ignition systems equipped with flame rectification.
2. Troubleshoot and service electronic proven pilot systems.

Direct Spark Ignition Systems

1. Explain the operation of each component of a direct spark ignition system equipped with flame rectification.
2. Troubleshoot and service direct spark ignition systems.

Intermittent Pilot Ignition (IPI) Systems

1. List and describe IPI heating control system components.
2. Describe the operation of an IPI heating control system.
3. Wire and operate a basic IPI heating control system.
4. Test system components and diagnose basic IPI system problems.

Hot Surface Ignition (HSI) Systems

1. List and describe HSI heating control system components.
2. Describe the operation of an HSI heating control system.
3. Wire and operate a basic HSI heating control system.
4. Test system components and diagnose basic HSI system problems.

C. Fan Assisted Venting Systems ..... 6 Hours

Heating/Cooling Appliance Venting

1. Describe and differentiate between common appliance vent categories.
2. Describe the operation of a fan assisted venting system.
3. Calculate required sizes of fan assisted venting systems for heating/cooling appliances.

SECTION FOUR: ..... ELECTRICAL SYSTEMS ..... 16 HOURS

A. Three Phase Fundamentals ..... 6 Hours

1. Describe the generation and application of three phase electricity.
2. Describe three phase connections and relationships.
3. Describe standard three phase wiring colour code.
4. Explain voltage and current relationships for three phase wye and delta.
5. Determine voltage and current.
6. Determine power, volts and amps in a three phase circuit.

B. Motors ..... 10 Hours

1. Describe the principles of motor operation.
2. Predict the effects on motor operation of load and voltage changes.
3. List five ways a motor may be overheated.
4. Identify the meaning and the application of motor name plate information.
5. Describe the operation and applications of three phase motors:
   a) describe methods used to change speed of three phase motors
   b) reverse a three phase motor
   c) identify and connect three phase motors including dual voltage, two speed, part winding and wye-delta
   d) list and identify the three phase connection methods used for motors
   f) label the terminals of a basic three lead 3 phase motor, wye or delta
   g) draw and label the graphic symbols for the commonly used three phase motors
6. Compare the application and operation of full voltage, part winding and wye-delta starting:

a) identify wye delta star
b) connect three phase motors for across the line starting using two wire and three wire control

SECTION FIVE: ..... AIR CONDITIONING THEORY ..... 32 HOURS

A. Air Conditioning Systems ..... 6 Hours

System Characteristics

1. Define the following air conditioning terms:
   a) air conditioning system
   b) comfort air conditioning
   c) industrial air conditioning
   d) year-round air conditioning
2. List and explain each component of a year-round and comfort air conditioning system.
3. List the conditioned variables controlled within a comfort zone.
4 Differentiate between air circulation and ventilation.
5. Differentiate between volumes and velocities of air circulation at various points on an air conditioning system.

B. Fans and Mechanical Drive Systems..... 4 Hours

Fans

1. Define a fan and how it moves air.
2. Describe and identify the three main types of fans.
3. Define the following terms as they apply to fans:
   a) blocked tight static pressure
   b) centrifugal or radial flow
   c) fan static pressure
   d) fan total pressure
   e) guide vanes
   f) impeller and casing
   g) propeller or axial flow
   h) wide open volume flow
4. Describe troubleshooting of fans

Mechanical Drives

1. Describe types of mechanical drives used in ventilation systems.
2. Describe types of devices that control static pressure in the ventilation system.

C. Advanced Air Properties ..... 8 Hours

1. Locate and identify the points and lines represented on a psychrometric chart.
2. Describe the following air conditioning processes and identify them on the psychrometric chart:
   a) air mixing
   b) combined cooling and dehumidification
   c) combined heating and humidification
   d) humidification
   e) evaporative cooling
   f) sensible heating
   g) sensible cooling

D. Air Instruments and System Balancing..... 4 Hours

Air Measuring Instruments

1. Describe the use of the following instruments:
   a) anemotherm
   b) flow hood
   c) picot tube and inclined manometer
   d) rotating vane anemometer
   e) sling psycho meter
   f) tachometer
   g) voltmeter
2. Determine air velocity and air volume from different types of ductwork using the calculation method and tables and charts.

E. Unitary Air Conditioning Systems ..... 6 Hours

Window Units

1. Identify and describe components.
2. List specific operating characteristics of window air conditioning units.
3. Troubleshoot using wiring diagrams.

Roof Top Heat/Cool Units

1. Identify heating and cooling system components.
2. List specific operating characteristics of roof top heat/cool units.
3. Describe pressures and temperatures on operating systems that use various refrigerants.
4. Use wiring diagrams to troubleshoot.

Packaged Room Air Conditioning Units

1. List various types of room air conditioning applications.
2. Identify system components.
3. List specific operating characteristics specific to package equipment.

Residential Air Conditioning Heating and Cooling

1. List the mechanical components of a residential system split system.
2. Install, service and troubleshoot residential systems, including:
   a) Charging of system
      i) start-up of system
      ii) wiring diagrams

Heat Pumps

1. Define heat pump.
2. Describe and classify heat pump systems.
3. Explain the following as they relate to heat pump systems:
   a) flow reversal
   b) volume of air
   c) supplementary and emergency heat
   d) wiring diagrams

Ductless Splits

1. Define a ductless system.
2. Describe the operation of ductless split.

Installation and Start-up

1. Describe system installation.
2. Complete a final system inspection.
3. Charge and start up a system.

F. Filtration ..... 4 Hours

Mechanical Filters

1. Describe the types, operation and servicing of mechanical air filters.

Electronic Filters

1. Describe electronic air cleaner operation.
2. Compare the operation and efficiency of air filters.
3. Describe the servicing of electronic air cleaners.

SECTION SIX: ..... AIR CONDITIONING SHOP ..... 32 HOURS

A. Fans and Belts ..... 4 Hours

1. Describe different types of fan wheels and operations.
2. Demonstrate WOCFM and BTSP.
3. Install various types of belts.
4. Demonstrate fan overloading and under-loading.

B. Ventilation Systems ..... 6 Hours

Installation and Troubleshooting

1. Use instruments to test BTU capacities of roof top units.
2. Use instruments to diagnose CFM problems.

C. Unitary Equipment ..... 20 Hours

Installation and Troubleshooting

1. Perform the following on window air conditioning units:
   a) read wiring diagrams
   b) install and troubleshoot
2. Perform the following on residential air conditioning units:
   a) read wiring diagrams
   b) install splits systems
   c) start-up system
   d) troubleshoot system

3. Peform the following on package systems:
   a) identify types of air and water systems
   b) read wiring diagrams.
   c) start-up system
   d) troubleshoot system

4. Perform the following on combination roof top units:
   a) read wiring diagrams
   b) install roof top unit
   c) start-up roof top unit
   d) troubleshoot roof top unit

5. Perform the following on heat pump units:
   a) read wiring diagram
   b) start-up heat pump
   c) check pressures in both heating and cooling modes
   d) troubleshoot air and water cooled units

6. Perform the followng on ductless split units:
   a) read wiring diagram
   b) install system
   c) start-up system
   d) check operation
   e) troubleshoot ductless splits

D. Air Instruments..... 2 Hours

Understand Applications

1. Use variety of air instruments to measure air flow on shop equipment.
2. Determine airflow using heat rise method.
3. Determine the air conditions using a psychrometric chart.
4. Determine cooling coil efficiency and perform the following:
   a) compare static pressure through various types of air filters
   b) observe problems using different types of filters. on the cooling coil

SECTION SEVEN: ..... CONTROL SYSTEMS ..... 8 HOURS

A. Pneumatic Control Systems..... 8 Hours

1. Describe the function, construction and operation of the primary components of a typical pneumatic building control system.
2. Identify components of a pneumatic compressor station.
3. Identify pneumatic sensors commonly used in building control systems.
4. Discuss the function, construction and operation of commonly used pneumatic transmitters.
5. Discuss the function, construction and operation of commonly used pneumatic actuators.
6. Define the following terms in the context of pneumatic building control systems:
   a) analog
   b) proportional band
   c) reset control
   d) throttling range
   e) set point
   f) offset/deviation
   g) dead band

h) under/over shoot

7. Create a pneumatic control schedule and program a single input pneumatic controller.

8. Discuss methods of interfacing building pneumatic control systems with building electrical and electronic control systems and include reference to the following:
   a) PE controller
   b) EP solenoid
   c) EP transducer

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SECTION ONE: .....REFRIGERATION SHOP.....48 HOURS

A. Industrial Compressor Tear-Down..... 10 Hours

Measuring Equipment

1. Demonstrate the proper procedures for compressor inspection and use of measuring instruments.
2. With emphasis on the following, describe all safety equipment required to dissemble an industrial compressor:
   a) safety footwear
   b) face and eye protection
   c) hearing protection
   d) proper protective clothing
   e) the use of lifting devices
3. Disassemble a compressor using manufacturers' instruction manuals
4. Identify internal parts and passages using manufacturers' manuals.
5. Measure moveable parts and compare to manufacturers' specifications to determine the amount of compressor wear
6. Re-assemble and check compressor rotation to ensure a proper overhaul has been completed correctly.
7. Generate a report on compressor condition.

B. Compound Compression Systems..... 8 Hours

General Compound System

1. Identify all of the components of a compound system.
2. Explain the proper start-up procedure of a compound system.
3. Perform the proper leak checking procedure on a compound system.
4 Complete a proper start-up and balance the system.
5. Set TX valves and water regulating valves for proper operation.
6. Compare compression ratios between stages.
7. Operate system to achieve a temperature of -100° F.
8. Diagnose why a compressor stops pumping
9. Create a report on the set-up and operation of a compound system.

C. Multiplex Systems ..... 10 Hours

General System Design

1. Identify all major components of a mulitplex system.
2. Describe the function of each component.
3. Describe lubrication circuits with respect to oil separators, reservoirs and oil float controls.
4. Perform proper start-up using manufacturers' instructions.
5. Set up controls and check the setting of metering devices.

Micro Processor Control System

1. Set temperatures on systems using evaporator pressure regulators.
2. Set heat reclaim system.
3. Set head pressure controls for winter operation.
4. Check system operations for proper temperature using the computer system.
5. Initiate defrost on freezer systems.
6. Perform a system pump-down and recover the refrigerant.

D. Centrifugal Operation and Inspection ..... .8 Hours

Inspection of a Unishell Centrifugal Chiller

1. Identify all components of a unishell chiller.
2. Inspect the water circuit of the evaporator and condenser.
3. Inspect the refrigeration circuits.
4. Inspect the oil circuit and oil pump assembly.

Disassembly of Centrifugal Compressor

1. Remove piping and split compressor.
2. Inspect impeller for cracks and wear.
3. Remove impeller and thrust bearing.
4. Inspect thrust shoes, pucks and leveling pads.
5. Inspect gear transmission.
6. Megger the motor windings.

Re-assembly of Compressor

1. Re-install bearings and impeller.
2. Check thrust clearance and proper rotation.
3. Complete re-assembly of chiller package.

E. Ultra Low Cascade Systems ..... 2 Hours

Start-up Procedure

1. Identify all components of the high and low stages of an ultra low cascade system.
2. Check electrical and control systems for proper wiring.

3. Start-up an ultra low cascade system and set all controls.
4. Operate system to a temperature of -60° F.

F. Artificial Ice Rinks ..... .2 Hours

Start Up, Service and Repair

1. Describe the charging, checking and adding brine to an ice rink (vented) system.
2. Describe the different types of rink floor design and their applications.
3. Define artificial ice rinks according to the B-52 Mechanical Refrigeration Code and reference the repair and the replacement of tubes.
4. Start up the ice rink simulator as per equipment instructions.
5. Set up all rink controls.
6. Perform proper flooding procedures to ensure smooth Ice surface.
7. Check the brine loop section of rink simulator with respect to the brine pump and inter-locking controls
8. Maintain proper ice temperature and thickness.
9. Perform a proper shut down of the ice plant simulator.

G. High Efficiency Purge Systems ..... 2 Hours

Operation of a High Efficiency Purge System

1. Describe the various applications for purge systems.
2. Describe the operation of a high efficiency purge system.
3. Start up a high efficiency purge unit.
4. Calculate the leakage rate from the purge unit.
5. Describe water separation and expelling of non-condensibles.

H. Microprocessor Control..... 6 Hours

General Applications

1. Describe the different applications for microprocessor controls.
2. Describe the general operation of a microprocessor with emphasis on the following areas:
   a) I/O board points
   b) over-ride systems
   c) canned program
   d) dip switch configuration
   e) remote access

Troubleshooting Microprocessors

1. Troubleshoot a microprocessor for problems in the following areas:
   a) I/O boards
   b) main processor
   c) end devices
   d) controls testing
   e) self-diagnostic system.

SECTION TWO: ..... REFRIGERATION THEORY ..... 24 HOURS

A. Industrial Refrigeration Systems ..... 6 Hours

Compound Compression Systems

1. Describe the following types of refrigeration systems and give examples of their applications:
   a) direct expansion
   b) flooded system
   c) liquid re-circulation system
2. Plot a pressure-enthalpy cycle diagram of a compound liquid overfeed system and explain the thermodynamics.

Industrial Refrigeration Applications

1. Describe industrial refrigeration applications including the following:
   a) freezer (industrial storage)
   b) gas plant (propane)
   c) other processes
2. State safety practices that apply to industrial refrigeration systems using R-717 and R-290 refrigerants.
3. Describe the components, the operation and the control of single stage and two-stage industrial refrigeration systems.
4. Describe the different piping practices used with industrial refrigeration systems.
5. Explain "re-circulation ratio" with respect to a liquid re-circulation system.

B. Piping Design ..... 2 Hours

Design of Piping Systems for Halogenated Refrigerants

1. Describe proper piping practices with respect to hangers and pipe slope on all lines.
2. List required pipe velocities required for proper oil return.
3. Describe the function of a trap with reference to the following:
   a) evaporators mounted above and below compressors
   b) condensers mounted above and below compressors
4. Describe piping for multiple compressors.
5. Describe how to properly pipe a liquid condensate line.

Piping Design for Ammonia Systems

1. Describe the steel pipe used for ammonia systems.
2. Describe the piping of an evaporative condenser.
3. Define the following and their applications:
   a) screwed fittings
   b) welded fittings
   c) flanged fittings
   d) compression fittings

C. Absorption And Centrifugal Chillers ..... 4 Hours

Lithium Bromide Absorption Chillers

1. Explain the principles of an absorption system.
2. Discuss the pressure and temperature relationship of R-718.

3. Describe the basic absorption cycle.
4. Describe and illustrate an equilibrium diagram.
5. Explain service and maintenance procedures for a standard absorption chiller.
6. Describe how to troubleshoot a chiller with reference to the following areas:
   a) machine additives
   b) taking a solution sample
   c) out-gassing

Centrifugal Chillers

1. Describe the motor cooling cycle.
2. Describe the lubrication cycle.
3. Describe the dehydration and purge cycles.
4. Read a centrifugal chiller electrical schematic and briefly discuss the start up procedure.
5. Explain the methods of capacity control.
6. Compare centrifugal chillers to reciprocating and helical screw compressor chillers.
7. Describe the function of the thrust balance disc and the labyrinth seals.
8. Describe the refrigeration cycle of a centrifugal chiller in both single stage and multistage.

Chiller Operation

1. Describe the compression cycle.
2. List and explain chiller barrel components and include baffles, tube sheet, passes, circuits, star inserts, range, approach and surge drum.
3. Determine the fluid flow rate and the pump head required for a chiller application.
4. Select a water chiller for a system at a given tonnage and operating within a specified range and approach.

Installation

1. Describe the installation of a chiller system and include:
   a) mounting
   b) piping
   c) cooling tower connections
   d) power wiring
   e) control wiring
   f) chilled water pumps
   g) all accessories
   h) storage tanks and pump-out units

Efficiency

1. Explain the function of the load demand limiter.
2. Describe the application of free-cooling with centrifugal chiller systems.
3. Describe the result of tube fouling, low velocity and erosion of the system's capacity.

Economizers

1. Describe the operation of the economizer cycle.
2. Describe and compare an open economizer system to a closed economizer system.
3. Explain the sub cooling cycle with an economizer and the refrigerant usage.
4. Describe the heat balancing load.

D. Multiplex Piping And Operation ..... 4 Hours

General Operating Systems

1. Describe the basic multiplex rack supermarket system.
2. Describe the operation of each of the following components:
   a) oil separator
   b) discharge pressure differential regulator
   c) heat reclaim valve
   d) split condenser valve
   e) EPRs with a suction stop feature
   f) satellite systems

Defrost Method of Multiplex Systems

1. Describe a hot gas defrost system and a cool gas system.
2. Explain the microprocessor method of initiating and terminating defrost.

E. Ultra-Low Systems And Cryogenics ..... 2 Hours

Low Temperature Refrigeration Controls

1. Describe low temperature control systems used on commercial ice cream and frozen food systems. Include all refrigeration and defrost components.

Cryogenics

1. Define cryogenics.
2. Give applications for the use of cryogenics.
3. List fluids used in cryogenics.
4. List safety precautions required when working on cryogenic systems.

Ultra-low Systems

1. Define an ultra-low refrigeration system.
2. Give examples of ultra-low system applications.
3. Describe the operation and application of cascade systems.
4. Sketch a cascade system that includes all components and a control schematic.
5. Sketch a compound system that includes all components and a control schematic.
6. Describe the purpose of compound systems for ultra-low applications.
7. List the refrigerants that are suitable for ultra-low refrigeration system.

Installation and Service

1. Describe the start-up and charging of a compound ultra-low system.
2. Describe the start-up and charging of a cascade ultra-low system.
3. State special precautions required in the installation and the servicing of cascade and compound systems.

F. Troubleshooting Systems And Components ..... 4 Hours

1. Troubleshoot oil failure control problems.
2. Troubleshoot compressor systems.
3. Read and interpret component layout diagrams.
4. Describe troubleshooting procedures on large industrial air conditioning and refrigeration systems.

G RELEVANT CODES ..... 2 HOURS

B-52 Refrigeration Code

1. Describe the section on administrative requirements.
2. Describe the section on system selection and application requirements.
3. Describe the section on design and construction.
4. Describe the section on precautions.

SECTION THREE: ..... HEATING THEORY AND SHOP ..... 32 HOURS

A. Troubleshooting Gas Fired Equipment ..... 16 Hours

Troubleshooting Procedures

1. Troubleshoot and correct the following heating appliance problems:
   a) appliance will not stop
   b) blower will not run or stop
   c) delayed ignition
   d) excessive heat
   e) gas odour at primary opening
   f) gas valve will not close
   g) gas valve will not open
   h) heating system corrosion
   i) insufficient heat
   j) main burner flame too large
   k) noisy motor/blower
   l) rapid burner cycling
   m rapid fan cycling
2. Identify and describe a systematic approach to troubleshooting.
3. Diagnose and remedy common system problems on heat/cool appliances.

Combustion Analysis

1. Identify the products of combustion involved in a combustion analysis.
2. Describe the procedure used in a standard combustion analysis.
3. Perform a basic combustion analysis on assorted types of equipment.

B. Operation of Roof Top Heat/Cool Units ..... 16 Hours

Roof Top Heat/Cool Units

1. Identify the common types of roof top heat/cool units.
2. Describe the operation of common roof top heat/cool units.
3. Operate and test various types of roof top heat/cool units.
4. Troubleshoot roof top heat/cool units.

SECTION FOUR: ..... ELECTRICAL SYSTEMS ..... 16 HOURS

A. Advanced Electrical Troubleshooting ..... 8 Hours

1. Compare various manufacturers' electrical systems.
2. Troubleshoot unitary systems.

B. Schematic Diagrams ..... 8 Hours

1. Interpret the following schematic diagrams:
   a) reciprocating chiller schematics
   b) centrifugal chiller schematics
   c) large compressor system schematics
   d) multizone HVAC units

SECTION FIVE: ..... AIR CONDITIONING THEORY ..... 48 HOURS

1. Air Conditioning Systems ..... 4 Hours

1. Describe static pressures with reference to the following:
   a) within the zone
   b) within the ducts and air terminal units
   c) at exhaust and intake louvers
2. Define the following:
   a) different areas of building
   b) types of occupancies
   d) single zone system
   e) multiple zone system
3. Classification of air conditioning systems.
   a) discuss and give examples of unitized equipment.
   b) discuss and compare central station air conditioning equipment.
4. Describe and provide examples of the differences between the following systems:
   a) all-air
   b) air-water
   c) all-water
5. Describe the operation of each of the following systems:
   a) constant volume single zone
   b) constant volume terminal reheat
   c) constant volume dual duct
   d) constant volume multi-zone
   e) constant volume face and by-pass

f) variable volume

B. Troubleshooting Air Conditioning Systems ..... 6 Hours

Noise

1. Discuss sound and noise.
2. Describe noise criteria as associated with diffusers.
3. Describe how to reduce noise in ductwork and buildings.

Air Conditioning Systems

1. Plot an operating air conditioning system on a psychrometric chart that involves:
   a) mixed air
   b) wet bulb
   c) dry bulb
   d) enthalpy
   e) by-pass factor
   f) oil apparatus dew point
   g) room sensible heat factor

Air flow Problems

1. Discuss the correct air velocity for cooling coils.
2. List problems resulting from incorrect velocities and volumes of air flow through cooling coils and describe how to correct these problems.
3. List reasons for low and high air flow rates and state methods to correct these problems.
4. List factors that affect coil bypass and explain how the bypass factor affects system performance.
5. Describe the relationship of the supply air to the saturated suction temperature and coil apparatus dew point.
6. Describe the different methods of measuring air flow.

Air Terminal Units

1. Explain the function of air terminal units.
2. State the differences between the following types of air terminal units:
   a) constant volume box
   b) dual duct mixing box
   c) terminal reheat box
3. Describe the application of a fan powered variable air terminal unit.

Air Balancing

1. Read mechanical drawings to determine design air volume flow rates for zones and diffusers.
2. Apply the First Fan Law to practical air handling problems.
3. Apply the Second Fan Law, which describes the relationship between fan head or total system resistance and airflow.

C. Air Conditioning Cooling Load Calculations ..... 6 Hours

Air Conditioning Loads

1. Discuss design problems using rule of thumb.
2. Define air conditioning load.
3. List the variables that effect load.

4. Define peak loads.
5. Define thermal lag.
6. Calculate the air conditioning load for a small commercial building and select equipment required for cooling.

D. Duct Systems and Filters ..... 6 Hours

Ducts

1. Describe the following types of air instruments used for measuring:
   a) velocity pressure
   b) static pressure
   c) total pressure
2. Define the following air distribution terms:
   a) air constant
   b) air terminal units
   c) balancing dampers
   d) connecting collars
   e) cross-breaks
   f) cushion heads
   g) diffusers and grilles
   h) duct transitions
   i) effective area
   k) fire and smoke dampers
   l) jet velocity
   m) K factor
   n) noise criteria
   o) primary air
   p) residual velocity
   q) secondary air
   r) standard air
   s) terminal velocity
   t) throw
   u) turning vanes
3. Describe the following duct systems:
   a) high pressure
   b) medium pressure
   c) low pressure

Duct Problems

1. Explain how to correct duct problems.
2. Describe friction loss in duct systems.
3. Discuss duct leakage (air) and its control.

Air Filters

1. List the types of air filters.
2. Describe the efficiency of various air filters.

E. Mechanical Drives for Fan Systems ..... 4 Hours

Fan Performance

1. List the operating characteristics of the following:
   a) propeller fan
   b) forward curved centrifugal fan

c) backward inclined centrifugal

2. Solve changes in the RPM, air resistance and horsepower of a fan/motor system using the three fan laws.
3. Describe the operating differences of blow-through and draw-through air handling equipment.
4. Describe the three fan classes, their rated conditions and how improper installations can reduce their performance.

Air Handlers

1. Check for fan imbalance.
2. List causes and solutions to the following air handler problems:
   a) high pitch (squealing) sounds
   b) low pitch (rumbling) sounds
   c) pulsating sounds
   d) vibration

Mechanical Drives

1. Troubleshoot complex mechanical drive system problems.
2. Compare the application of a direct drive mechanical coupling to a belt drive system.

F. Specialized Control Systems ..... 4 Hours

Central Station Air Conditioning

1. Describe control systems for the following central station air conditioning systems:
   a) air system
   b) water system
   c) air and water system

G. Installation of Air Conditioning Equipment ..... 6 Hours

Locating Equipment

1. Describe the following installations:
   a) rooftop air conditioning unit
   b) through-the-wall air conditioning unit with a condensing unit mounted on a pad or on a roof
2. Install indoor package units that are water cooled, equipped with an air cooled remote condenser or equipped with a dry cooler.
3. Describe unit installation based on:
   a) rigging
   b) hoisting
   c) placement of the unit
   d) supports
   e) condensate drain connections
   f) duct connections
   g) power supply
4. Describe the installation of residential and commercial direct expansion systems.
5. Describe, including reference to the following, the installation of condensing units and compressor units that are equipped with remote condensers:
   a) make all the necessary refrigeration piping connections
   b) accessory installation
   c) piping supports
   d) piping insulation

Start up

1. Describe a system start up.
2. Check and correct capacity control devices.
3. Check and adjust delivered air.

Maintenance

1. Describe a system maintenance procedure sheet, based on manufacturer specifications, and include system start up ,shut down and periodic maintenance.

H. Energy Management and Indoor Air Quality ..... 4 Hours

Indoor Air Quality

1. Describe the following concepts:
   a) effective temperature
   b) mean radiant temperature
   c) thermal shock
2. Describe solid, liquid, gaseous, organic, smoke and smog contaminants and their cost to public health and the economy.
3. List the sources and the detection of these contaminants as related to air conditioning equipment operation and installation.
4. Describe the control of contaminants using air conditioning equipment.

Air Conditioning Efficiency

1. Explain the adjustment of cylinder unloading and other capacity controls.
2. Discuss the application of free cooling for package air conditioning systems.

Energy Management Systems.

1. Describe the applications of the following heat recovery systems:
   a) run-around loops
   b) heat wheels
   c) heat
2. Discuss the advantages and disadvantages of night set-back thermostats and the use of fan cycling.

I. Advanced Blueprint Reading ..... 8 Hours

1. Interpret the following information from a standard set of mechanical blueprints:
   a) refrigerant piping layout
   b) ductwork and diffusers
   c) equipment location
   d) as built drawings

SECTION SIX: .....AIR CONDITIONING SHOP.....16 HOURS

A. Installation ..... 4 Hours

Install Air Conditioning Equipment

1. Start up various units.
2. Check the start-up procedures.

3. Record the information.

B. Instruments ..... 6 Hours

Select and Use Iinstruments

1. Measure air flow from various units.
2. Calculate the air velocity.
3. Calculate air volume.
4. Plot on psychrometric chart.

C. Troubleshooting ..... 6 Hours

Troubleshoot Air Conditioning Equipment

1. Interpret wiring schematic diagrams.
2. Diagnose system problems.
3. Determine air conditioning system efficiency.

SECTION SEVEN: ..... .ADVANCED CONTROL SYSTEMS ..... .56 HOURS

A. Circulating Pumps ..... 12 Hours

1. Identify the components of a centrifugal pump
2. Describe the operation of a centrifugal pump and include the following terms:
   a suction head
   b) discharge head
   c) total head
3. Describe the implications of pump cavitation in terms of NPSHR and NPSHA.
4. Determine the performance of a centrifugal pump using the system curve and pump curve.

B. Electromechanical Systems ..... 20 Hours

RTU Heat/Cool Controls

1. Describe control systems for the following applications:
   a) unitary RTU
   b) two-duct system
   c) face and by-pass
   d) multi-zone
   e) VAV
   f) preheat/reheat
2. Compare a hybrid control system with an electromechanical control system.
3. Describe the diagnostic techniques and instruments used to troubleshoot a complex multi-zone hybrid control system.

Specialized Control Applications

1. Program a commercial electronic night set-back thermostat.
2. Troubleshoot problems on the following simulators:
   a) domestic refrigerator

b) water cooled air conditioning
c) split system
d) chiller
e) multiplex refrigeration system
f) heat pump

C. Economizers ..... 14 Hours

1. Draw a flow chart detailing the sequence of operations and interactions of a unitary HVAC system that uses a "free cooling" economizer.
2. Describe the function and operation of the following economizer controls and accessories:
   a) ambient lock out
   b) economizer relay
   c) economizer transformer
   d) enthalpy control
   e) mixed air control
   f) minimum positioner
   g) high/low limits
   h) two and three wire
   i) load sequencer operation
   j) night switch
3. Explain the function and operation of these modulating motor components:
   a) balance relay
   b) feedback pot
   c) return spring
   d) end switches
4. Draw a schematic ladder diagram that combines a unitary HVAC RTU and an economizer and construct an actual system as designed.

D. Back Flow Prevention ..... 2 Hours

Back Flow Devices

1. Describe the requirement for back flow prevention in the refrigeration and HVAC industry.
2. Discuss the following methods of back-flow prevention:
   a) air gaps
   b) double check valve
   c) reduced pressure valve
3. Describe the installation and testing requirements of back flow prevention devices.

E. Computerized Systems ..... 8 Hours

Major Building System Control Systems

1. Retrofit a building automation system to an existing electromechanical control system.
2. Program one component of a building automation system.

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